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DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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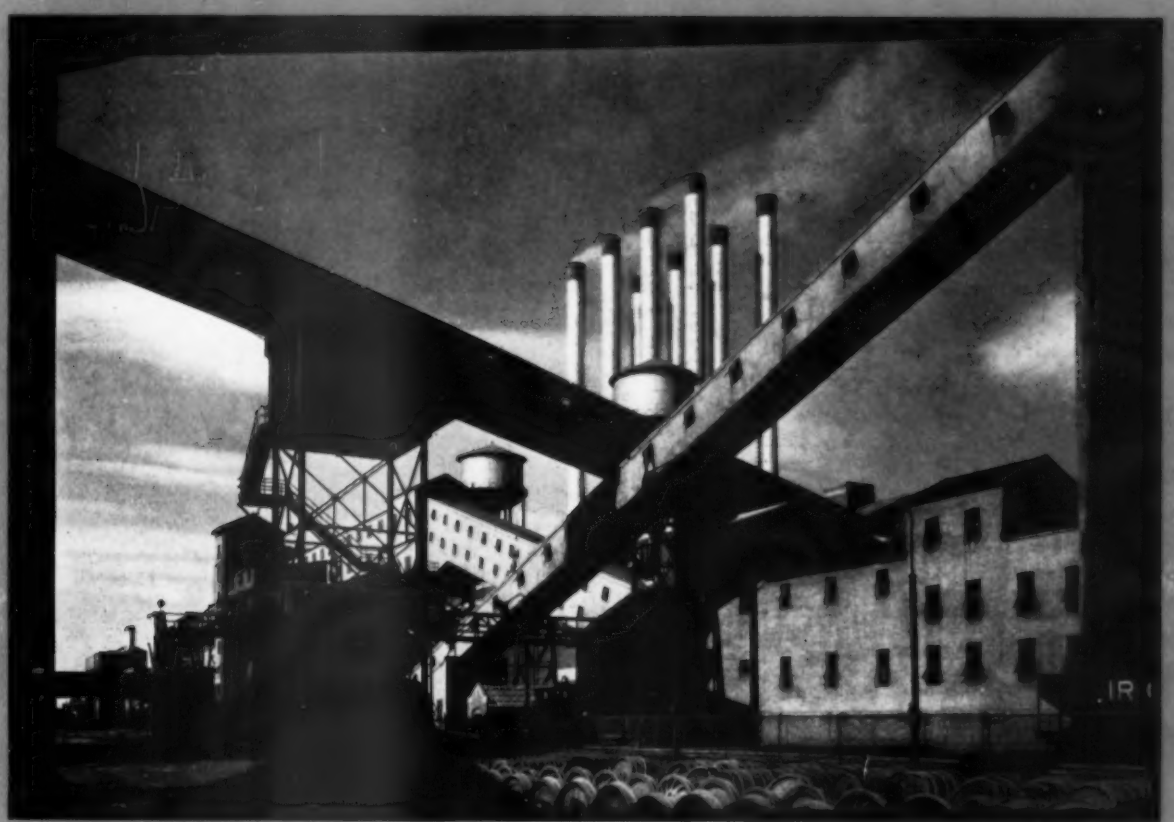

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Reading Modernizes its Power Plant

Breaker Bars for Traveling Grate Stokers

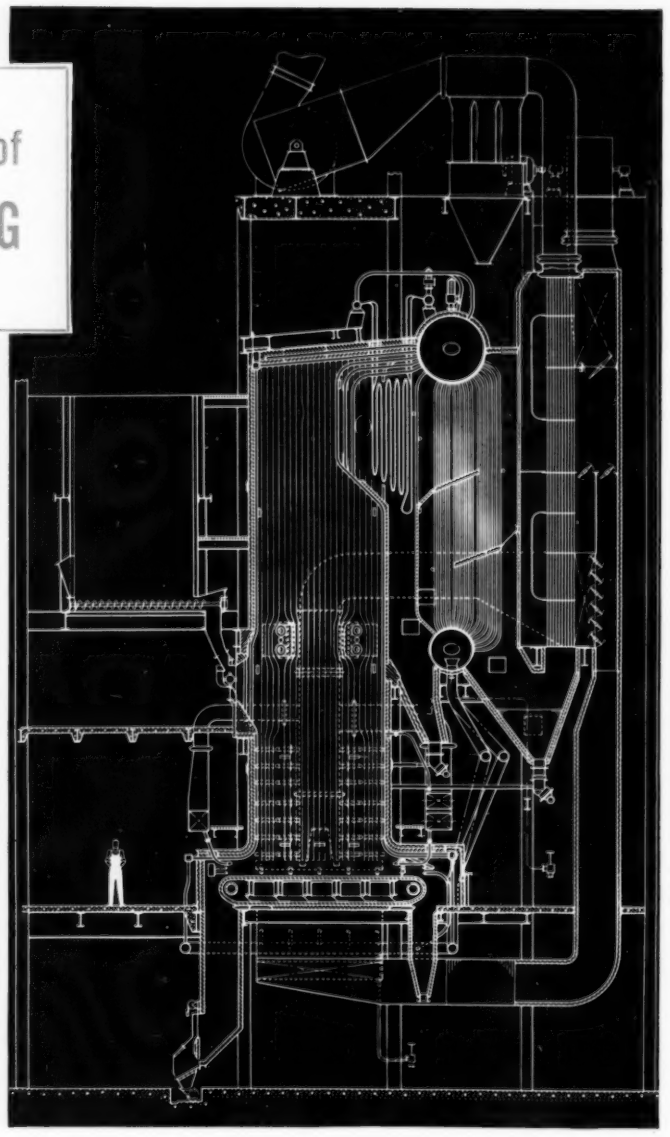
Influence of Low-Quality Coal

Now you can Burn Bark

reliably • efficiently • economically . . .

. . . with the new C-E method of

SUSPENSION BURNING



Here is a revolutionary, new bark burning method – proved in service – that will soon be paying impressive dividends to prominent pulp and paper mills all over the country. Several companies have units, similar to that illustrated, in service, under construction or on order.

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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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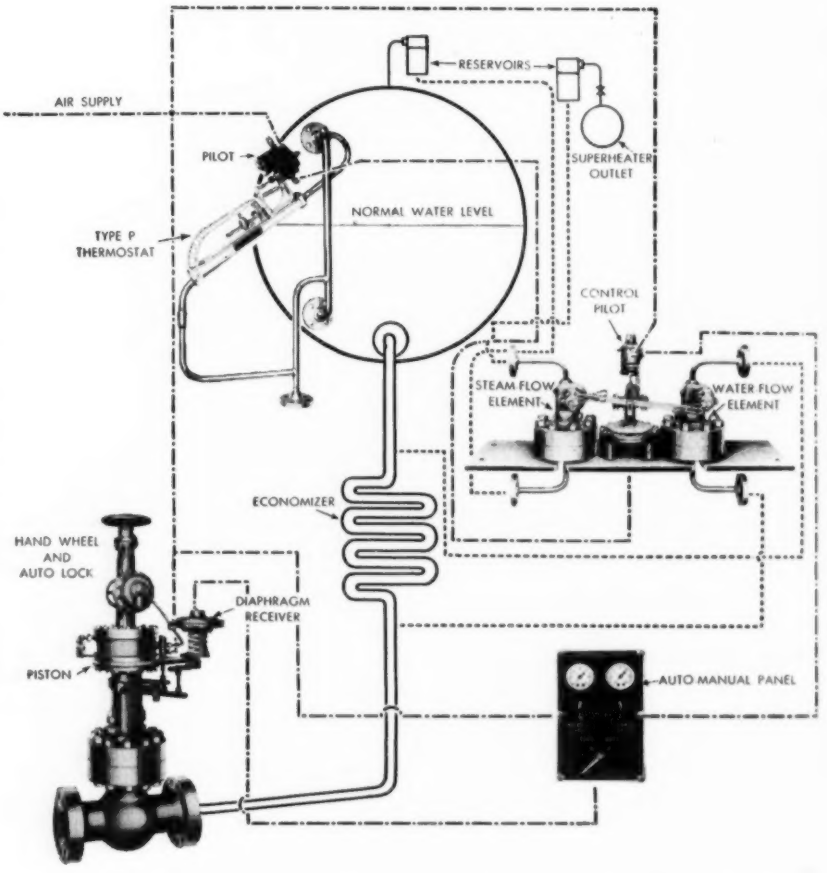
	1	B & W	1600	860,000



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Editorials

Steam-Electric Utility Survey

The Federal Power Commission has recently issued its fourth annual report covering "Steam-Electric Plant Construction Costs and Annual Production Expenses" for the calendar year 1951, together with a summary of "Statistics of Electric Utilities in the United States" for the same period. These reports, which deal with privately owned utilities, contain a mass of interesting data, both physical and financial, from which a few pertinent facts are here cited.

At the beginning of 1952 there were three hundred Class A and Class B privately owned electric utility companies in the United States with total assets of $22\frac{1}{2}$ billion dollars and an installed capacity in excess of sixty million kilowatts. These utilities operated 2089 generating plants of which 689 were steam. However, the steam plants produced 83 per cent of the total power generated, a fact that is most important.

The report covers a survey of 305 of the larger steam stations which, although less than half of the total number of steam stations, represented over forty million kilowatts of installed capacity, or 73 per cent of the total steam-electric capacity and over two-thirds the total capacity of all types—steam, hydro and diesel. Thirty new plants are stated to have been placed in service during 1951 and over a hundred were reported as projected or under construction.

Plant investment costs are shown to have increased 75 to 100 per cent since 1938 despite the wide acceptance of outdoor and semi-outdoor station designs, and the employment of very large units with the single boiler per turbine arrangement.

Fuel ranged from 65 to 80 per cent of the total production cost and, of the plants surveyed, the net station fuel rate, in coal or coal equivalents, was 1.14 pounds per kilowatt-hour, which was slightly under the national average. Six steam stations reported a net heat rate under 10,000 Btu per kilowatt-hour. Five employed reheat and the sixth the mercury-steam cycle. The lowest heat rate was 9354 Btu per kilowatt-hour for steam conditions of 2000 psig and 1050 F steam temperature. With more and more reheat installations going into service, figures when compiled for 1952 should show in the "under 10,000 Btu" category.

A significant fact, traceable to the increased use of automatic controls, improved plant layouts and reduction in number of units for a given capacity, was the greatly reduced number of operators per thousand kilowatts. This ran as low as 0.31 for one coal-fired station, which was bettered by a number of gas-fired plants. This is less than a third of the figure for twenty-five years ago and offsets the doubling of operating wages.

Although this survey carried only to the end of 1951, for capacity that has thus far gone into service in 1952, one may look to the Commission's current monthly reports. On September 29 it reported that, as of August 31, 1952, the total installed electric utility capacity (privately and publicly owned) was slightly over 78 million kilowatt-hours, which represented an increase of some five million kilowatts in twelve months.

A Return to Fundamentals

Physics is the basic physical science. How important it is to the engineer is emphasized by these thoughts from a stimulating pamphlet entitled "How to Study Physics" by Seville Chapman:

"All professional students should be impressed with the fact that their technical knowledge rapidly goes out of date, not because it is wrong but because new and better methods and techniques are developed. It has been estimated that the useful 'half-life' of technical knowledge is about ten years."

The truth of these statements was strikingly illustrated at the Thirteenth Annual Water Conference, a report on which appears elsewhere in this issue. By way of an appropriate example, a knowledge of the theory of ionization and the electromotive force series of elements aided in the comprehension of a paper on the use of metallic phosphates in cooling-water treatment. Or in another instance, a recently devised testing technique for measurement of corrosion rate could be appreciated most readily by those having a sound understanding of the theory of galvanic (electrolytic) cells and of the fundamental electrical conduction properties of a capacitor (condenser).

How much of the engineering curriculum should be devoted to basic science and how much to technological applications has been interminably debated by leaders of industry and of engineering education. The outstanding achievements during World War II by physicists and chemists, whose experience and training were largely derived from highly specialized theoretical research, placed renewed emphasis upon the value of fundamentals as a means of training *versatile* graduates capable of adapting themselves to rapidly changing technological conditions.

Engineering educators have generally recognized this. The trend in engineering education has definitely been toward a combination of basic training in science and cultural broadening in the so-called humanistic-social studies. As a consequence, certain cherished engineering specialties have been forced out of the curriculum in some schools which choose to maintain the traditional four-year college program. Now, however, the engineering graduate should be equipped with intellectual tools that will make him more versatile as a professional practitioner and more understanding of his responsibilities as a citizen. In this sense engineering as a profession greatly benefits by a return to fundamentals.

Reading Modernizes Its Power Plant

By B. R. WHEELOCK, JR.
Mechanical Engineer, Gilbert Associates

Six out of fourteen vertical 250-hp boilers, installed in 1901–1905, were replaced by one modern, two-drum unit of 60,000 lb per hr capacity to carry total summer and base winter load of the Reading Railroad shops and offices. Anthracite fines are burned on a traveling grate stoker.

THE extensive railroad car and locomotive repair shops of the Reading Company are located within the city limits of Reading, Pa. The line is one of the Nation's major railroads, the largest anthracite carrier, and the fifth largest tonnage carrier in the United States. Construction of the locomotive shop at the turn of the century included a new power plant to meet the augmented steam demand of new equipment. This load was made up of steam-driven air compressors, reciprocating engines, steam hammers, process requirements and heating for the widespread shops, offices and stations. In later years this load was increased by elimination of other boilers at various locations. Fourteen 250-hp, 150-psig saturated-steam, vertical, masonry-setting, Wickes water-tube boilers were installed, eight in 1901 and six in 1905. Each boiler consisted primarily of two circular drums connected by vertical straight tubes divided by a fire-brick tile baffle which passed through the center and formed two gas passes. Hot gases leaving the furnace swept upward to the bottom of the steam drum, then reversed and passed downward to leave the unit at the bottom rear where they passed into a duct beneath the operating floor which led to the base of the stack (see Fig. 1). The furnace was of "Dutch oven" construction, built in front of the boiler setting, and fired with a Roney mechanical stoker which was designed to burn anthracite buckwheat from an overhead bunker.

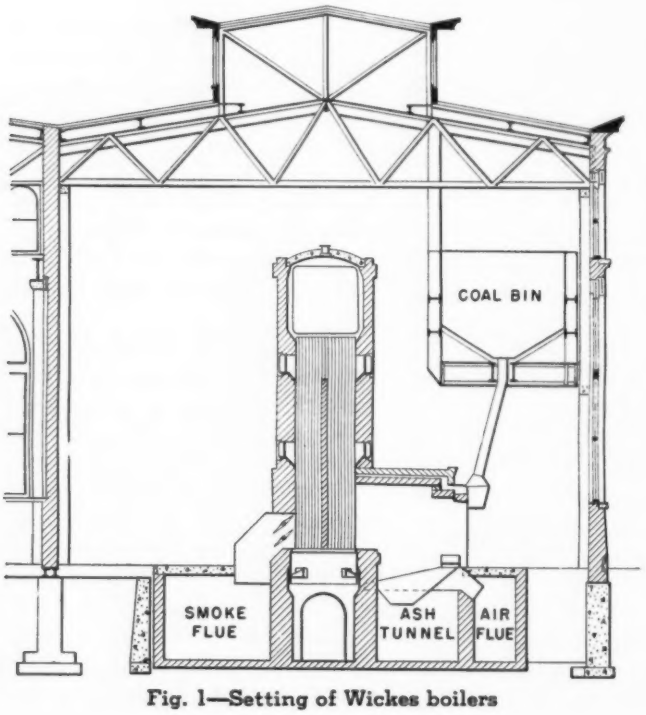


Fig. 1—Setting of Wickes boilers

Fig. 2—Firing aisle of original boilers; forced-draft duct beneath floor

Combustion air for all fourteen boilers was supplied by a 15-ft diameter radial-blade fan through a duct that extended beneath the operating floor the entire length of the building. The installation typified good central station steam design for the early twentieth century period, the general arrangement of the boiler house being as indicated in the cross-section, Fig. 1. The appearance of the boiler room before modernization, after a half century of continuous operation, may be seen in Figs. 2 and 3 which show, respectively, the firing aisle and top view of the 1901–1905 Wickes boilers.

The postwar years brought continuously increasing maintenance costs and the possibility of pressure derating of the Wickes boilers. These conditions justified an extensive study of the present and projected future steam requirements by the Reading Company and their consulting engineers. The outcome was a decision to remove six of the Wickes boilers located at the north end of the plant and in their place to install a single modern steam generator and auxiliaries arranged to provide space for a future duplicate unit.

Design Considerations

Study of requirements and the reduced efficiency due to age of the remaining eight boilers dictated a capacity of 60,000 lb per hr continuous for the new steam generator. This capacity is sufficient to meet the entire steam demand for the summer months and the base load throughout the remainder of the year. Supplementary steam will be furnished as required by placing existing boilers in service. The possibility of operation at a higher pressure in the future indicated the selection of a unit designed for 200 psig maximum pressure. The far-flung steam distribution system, a network approximately

Fig. 3—Top view of Wickes boilers

$1\frac{1}{2}$ mi in length and $\frac{1}{4}$ mi wide, necessitated the production of superheated steam in order to reduce condensation in the steam lines.

Initial investment and economical operation were fundamental considerations in the design of this installation. Since the Reading Company is the principal carrier of anthracite an adequate supply of this fuel is assured. Although anthracite is available at relatively low cost in this area, studies of various steam generator designs revealed that an economizer would be justified for partial heat recovery. Further study indicated that the coarse combustible particles in the fly ash should be recovered and reinjected into the furnace for additional economy. The entire installation was to be designed to minimize manual labor required for operation and maintenance.

The question of gas passes in the boiler section of the new steam generator was among the initial considerations. Anthracite fly ash particles are highly abrasive and exert a considerable cutting action when propelled at high velocities. This situation results in boiler tube erosion and severe baffle wear. Multipass boilers are characterized by relatively high draft losses which increase induced draft fan energy cost. Comparison of various boiler designs for this installation revealed that the gas velocity of the single-pass design was approximately 36 per cent of that of the corresponding velocity of a multipass design. This factor led to the selection of the single-pass boiler.

Space considerations included the requirement that the installation was to be laid out to accomodate a future similar steam generating unit and auxiliaries. Space was also to be allocated on the operating floor for future installation of three centrifugal boiler feed pumps. This contemplates steam-turbine-driven and motor-driven pumps which would adequately serve the entire plant, furnish low-pressure steam for deaerating feedwater, and replace the existing isolated reciprocating boiler-feed pump room.

Steam Generating Equipment

A Combustion Engineering-Superheater, Inc., steam generator, Type VU-X, of the two-drum single-pass design meeting all the requirements was selected. The unit which is shown in Figs. 4 and 5, is complete with a 19-element Elesco interbank superheater, designed to provide approximately 50 deg of superheat, water walls and water-cooled front and rear arches, also an Elesco finned tube, separately set economizer having 1000 sq ft of heating surface, all designed for a maximum boiler pressure of 200 psig. The boiler section has a total heating surface of 10,655 sq ft. It is fired with a C.E. Type L traveling grate stoker 20 ft long and 11 ft wide, capable of burning either No. 3 or No. 4 buckwheat anthracite. Stoker siftings are continuously removed to the ashpit by means of a screw conveyor. Coarse fly ash particles containing appreciable combustible material are collected from the gases in two banks of three hoppers located on each side of the lower drum and reinjected into the furnace under the rear arch for reburning.

Feedwater System

All makeup water for the plant is taken from the Maiden Creek Pumping Station supply of the City of Read-

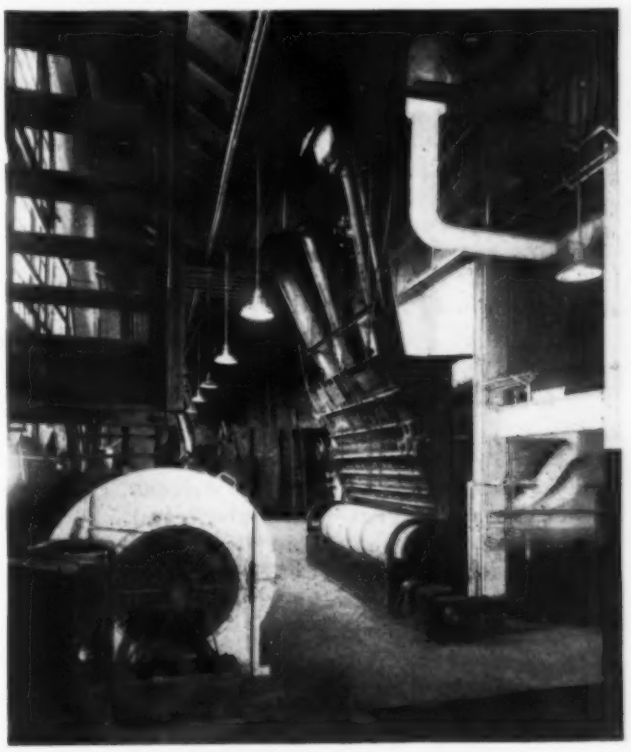


Fig. 4—Front of 60,000-lb per hr unit with forced-draft fan at left; old units in background

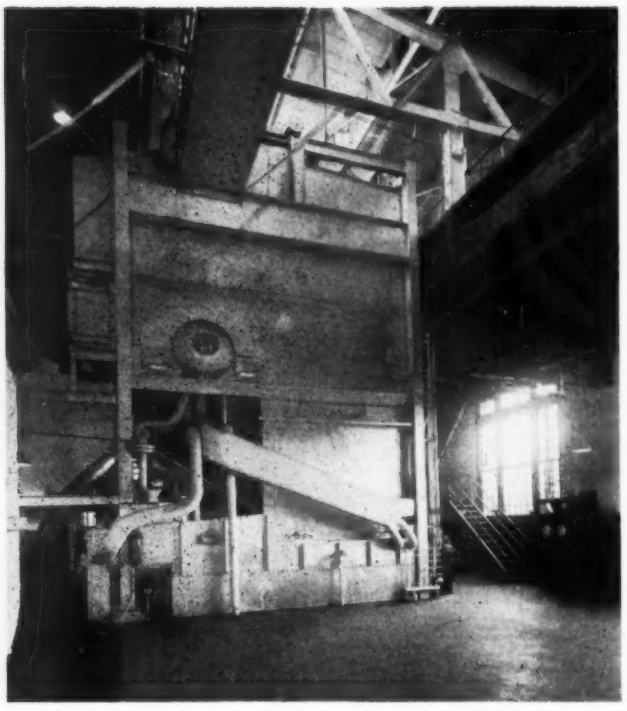


Fig. 5—Left side of new boiler with the control panel at extreme right

ing, primary water conditioning facilities having been designed to supply 100 per cent makeup to the entire boiler plant. The water supply for the boilers is drawn primarily through the engine room as cooling water prior to its reaching the boiler plant. A low-level control valve located upon the deaerator storage tank bypasses the engine room to make up any deficiency in the water supply to the boiler room. Two sodium-cycle pressure-type cation exchangers with sulphonated polystyrene beds, each large enough to carry the full makeup demand have been installed. These units are $6^1/_2$ ft in diameter by 5 ft high on the straight side, ASME Code fabricated for 100 psig and protected internally by an industrial type baked-on phenolic lining. Each is capable of softening 273,750 gal of 5.3 grains per gallon hardness as $CaCO_3$ between regenerations at a maximum flow rate of 125 gpm. The softeners are employed upon an alternating cycle; the individual water meters with integral alarms warn of the imminence of exhaustion of a resin bed.

Softened makeup water is admitted through a float-operated valve to the deaerating feedwater heater shown in Fig 6. This unit is designed with sufficient capacity to serve both the new and the old boilers. It will heat to approximately 220 F the full boiler feedwater flow of 120,000 lb per hr and deaerate the water to 0.03 cc per liter of dissolved oxygen. The feedwater enters the unit through a spray-type internal-vent condenser and cascades over a series of trays until deaeration and heating to saturation temperature have been achieved. All internal parts were fabricated from stainless steel. A horizontal cylindrical storage tank of 5000 gal capacity is located below the deaerating section and affords approximately 20 min water supply at full load. Either auxiliary exhaust steam or live steam drawn from the main steam line through a pressure-reducing station is supplied to the deaerator.

Currently an existing reciprocating boiler-feed pump room remains in service to feed both the new and the old boiler installations. Feedwater supply to the economizer of the new steam generator is controlled by a Bailey air-operated flow regulating valve. Under full load, feedwater enters the economizer at approximately 220 F and leaves at about 255 F.

The National Aluminate Corp. acts as the boiler feedwater consultants to the Reading Company. Nalco gravity-type ball feeders have been supplied to introduce Nalco Ball Compound No. 75 (a lignin derivative with a foam suppressant agent) to the water entering the deaerator and to introduce Ball Compound No. 19 (catalyzed sodium sulfite) into the deaerator storage tank.

Secondary water conditioning is effected by means of a chemical mixing tank and employment of a solution feed pump. Nalco Compound No. 77 (a sodium lignin organic orthophosphate) is dissolved in the tank. One side of the adjustable-stroke duplex chemical pump discharges to a perforated header in the steam drum of the new steam generator and the other side of the pump discharges into the boiler feed pipe line extending to the remaining Wickes boilers.

Full provision has been made for condensing and cooling steam samples and cooling samples of boiler salines and feedwater for the new unit. Analysis of these samples and chemical treatment work is supervised by the chemical laboratory of the Reading Company.

Draft Equipment

Combustion air is furnished to the stoker by a motor-driven centrifugal fan capable of producing 22,000 cfm of 100-F air at 4.0 in. H_2O static pressure. The inlet air is vane controlled.

Flue gases from the economizer pass directly into a mechanical-type dust collector where at least 80 per cent of the particles that will be retained on a 200-mesh screen are removed with a maximum draft loss of 0.20 in. H_2O. The performance of this collector meets the specifications and requirements of the ASME Model Smoke Regulation Ordinance.

A short breeching extends from the dust collector to the induced-draft fan on the operating floor, a unique feature being utilization of the existing flue-gas duct

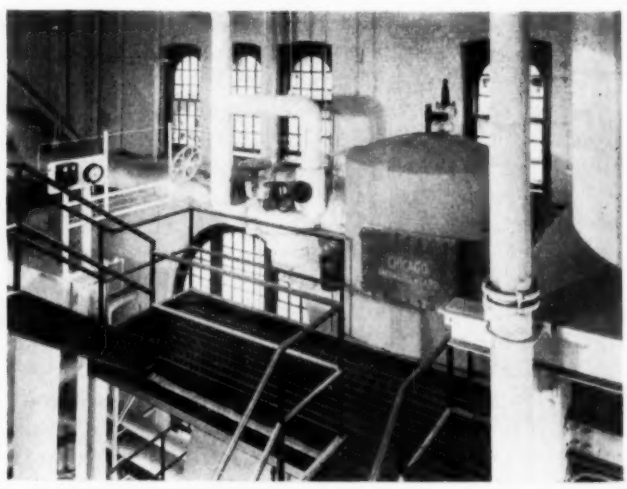


Fig. 6—Upper portion of deaerating feedwater heater showing part of ash-storage bin at right, ash-conveyor pipe and some of the piping

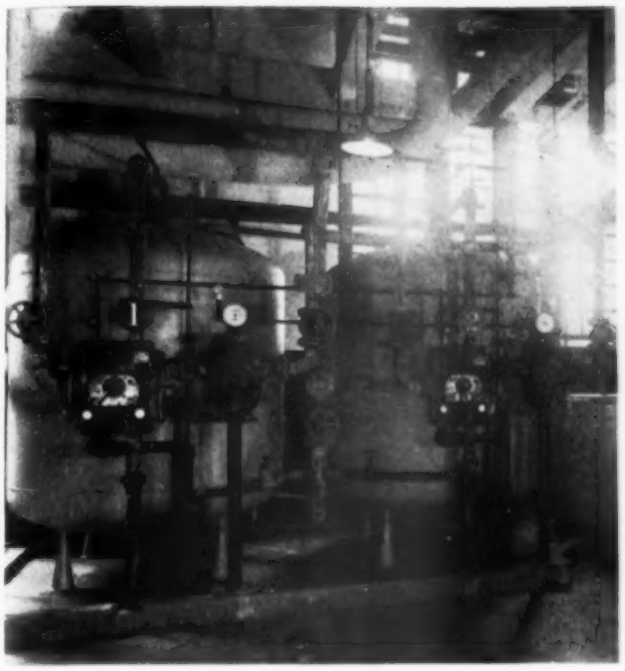


Fig. 7—Sodium-zeolite water softeners

beneath the operating floor to convey flue gases from the induced-draft fan outlet to the base of the chimney. A portion of this duct was rebuilt to serve the new installation thereby permitting the induced-draft fan location in an accessible position on the operating floor. A better design was thus effected and the cost of the usual platforms and extensive breeching connection into the chimney were eliminated. The induced-draft fan is a centrifugal type with double-inlet boxes and both inlet and outlet flow-control louvres. The inlet louvres are automatically controlled and the outlet louvres remain in an open position. The latter are intended only to enable the fan to be isolated for repair should a second fan be installed in the future.

The new steam generator is served by an existing brick stack 200-ft high (above grade), partly refractory lined and 11 ft in diameter at the top.

Ash Removal

Cinder from the stoker ash hopper, as well as the fly ash from the dust collector hopper, and fly ash which may settle in the base of the chimney, are removed with a pneumatic ash conveying system and discharged into an elevated vitrified tile ash-storage bin located in the top portion of the building. Cinder and dust are periodically chuted by gravity into hopper cars positioned on the boiler plant coal- and ash-handling railroad siding east of the plant. Dust arising from this transfer operation is suppressed by water sprays integral with the chute arrangement. Inherent cleanliness was desired in this installation, hence the air employed to convey ash and dust is passed through two centrifugal-type separators arranged in series on top of the storage bin and is finally scrubbed by a water spray before being discharged to the atmosphere. The system is actuated by steam ejectors located after the secondary separator, thus creating a negative pressure within the system. Air is drawn into the system through air intakes located at the inlet points. This flow of air sweeps the ash and cinder particles into the separators which discharge periodically into the storage bin.

Control Equipment

Boiler-drum water level is maintained automatically with an air-operated two-element type control. Combustion rate is also automatically controlled to maintain a constant steam pressure regardless of load variation. Pneumatically operated controllers vary fuel feed, forced-draft air, and induced draft in proportion to steam load to effect fully automatic operation. The panel shown in Fig. 5 is the center of the control of the boiler. Here operation may be switched from automatic to manual. The following performance information is either indicated and/or recorded at this panel:

Steam pressure (recorded and indicated on gage)
Water level (indicated)
Windbox draft (indicated)
Furnace draft (indicated)
Uptake draft (indicated)
Steam flow (indicated, recorded and integrated)
Flue gas flow (indicated and recorded)
Flue gas temperature (indicated and recorded)
Steam temperature (indicated and recorded)
Feedwater temperature (indicated and recorded)

The recorded information supplemented by operator logged instrument readings affords operating management the essential heat-balance data required to check the operating economy of the new steam generator.

A multi-unit draft gage is conveniently mounted to guide firemen in correct adjustment of the stoker zone dampers. Each of the seven gages indicates the under grate pressure within the zone to which it is connected.

Construction work began with the dismantling of the six Wickes boilers late in May 1951. The new installation was placed in continuous operation in April 1952, approximately eleven months after the beginning of construction.

MAJOR EQUIPMENT:

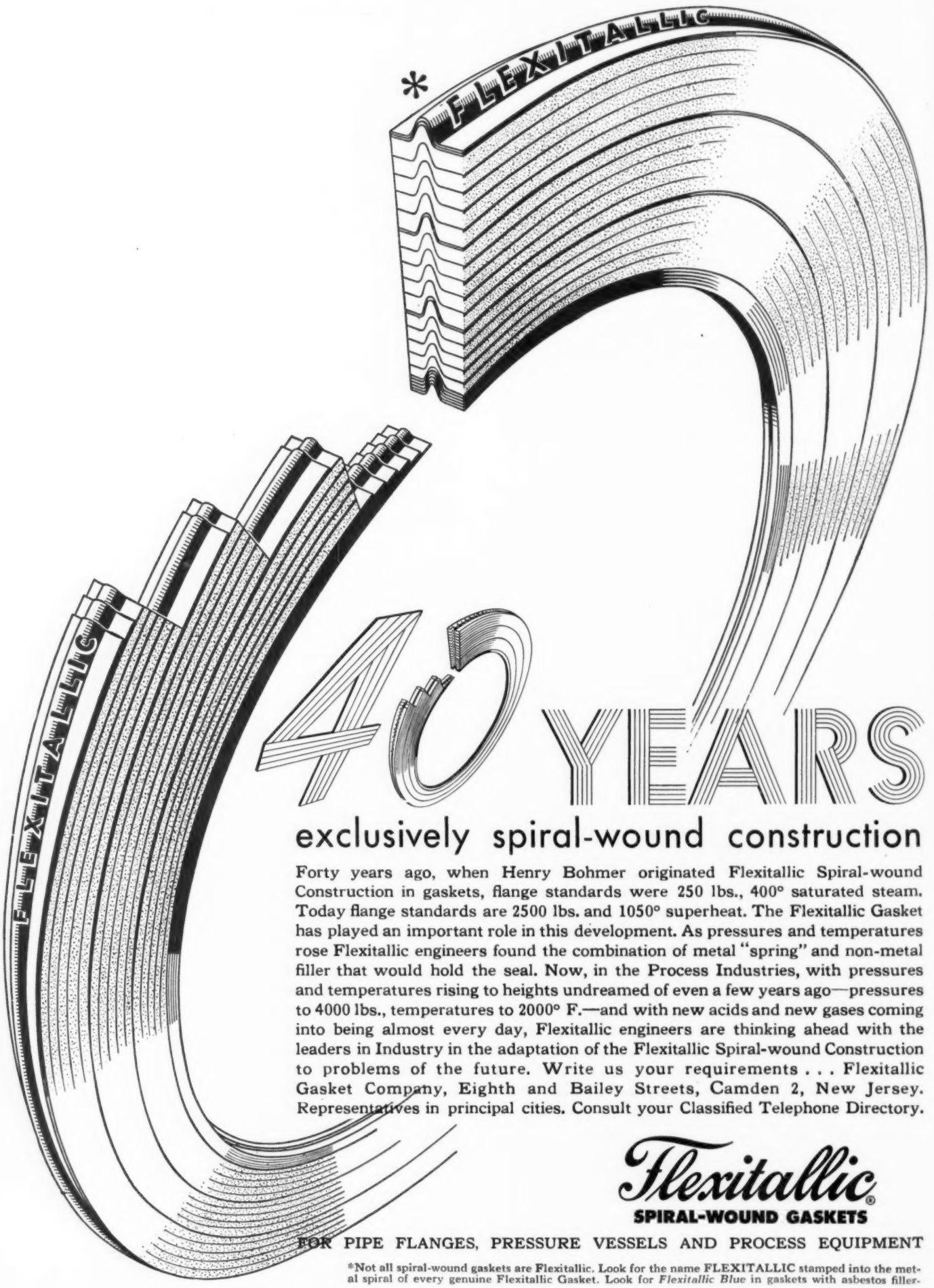
Steam generator	Combustion Engineering-Superheater, Inc.
Forced and induced-draft fans	Westinghouse Electric Corp. (Sturtevant Division)
Dust collector	Green Fuel Economizer Co.
Water softeners	Cochrane Corp.
Secondary water-treating equipment	National Aluminate Corp.
Deaerating feedwater heater	Chicago Heater Co.
Ash conveyor and storage bin	United Conveyor Corp.
Combustion control, boiler-level control and instruments	Bailey Meter Co.

Design and Construction

Gilbert Associates, Inc., of Reading, Pa., served as designing and consulting engineers. Acting as contractors were: L. H. Focht & Son, Inc., Wertz Engineering Co., both of Reading, and M. A. Hospador, Pottsville, Pa., also Howard T. Roe Co. of Havertown, Pa., and the Armstrong Cork Co. of Philadelphia.

Acknowledgment

The author wishes to express his appreciation to the Reading Company for permission to publish this article.



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Breaker Bars for Traveling Grate Stokers

By WALTER GREACEN, III
Chief Mechanical Engineer
New York State Electric & Gas Corp.

The purpose of this article is to show how a very simple and inexpensive device materially increased the capacity and economy of operation of several traveling grate stokers when burning No. 4 buckwheat with a high quantity of undersize.

DURING the first several years of operation at Jennison Station, our anthracite fuel supply was from one source and of excellent quality. Unfortunately, this supply became less available and we were obliged to procure fuels from several other sources. All our fuel purchases were made under rather rigid specifications, particularly as to sizing; however it was not uncommon to receive shipments containing a greater percentage of undersize than was specified. To take sieve analysis of each car to determine whether or not specifications were met is too time consuming and only where visual inspection showed very definitely high undersize was it practical to set a car aside to prove by sieve analysis that it failed to meet specifications and reject it.

This particular plant has four boilers, each of 200,000-lbs per hr capacity with traveling grate stokers 24 ft wide by 28 ft-long as shown in Fig. 1. When the second unit went into operation in 1950, we were obtaining No. 4 buckwheat from about 20 suppliers and difficulties were being encountered in obtaining full capacity with certain fuels.

Our storage bunkers hold approximately 28 cars. The conveying system includes a screw conveyor across the top of the bunker approximately 175 ft long. It was not uncommon to be operating at normal capacity for several hours and then for no apparent reason other than change in fuel to have the capacity fall off anywhere from 20 to 35 per cent. Conditions on the fuel bed showed mounding of unburned and only partially ignited fuel traveling toward the ash pit, eventually discharging therewith, of course, very high carbon loss. It was evident that air was not penetrating the fuel bed uniformly.

The operators were experienced but all attempts to manipulate air supply to the various zones both across and throughout the length of the stoker failed to overcome the mounding with the resulting loss in capacity and economy. Conditions appeared to be considerably worse on boilers No. 3 and No. 4 than on the initial units No. 1 and No. 2. Since the fuel fed to No. 4

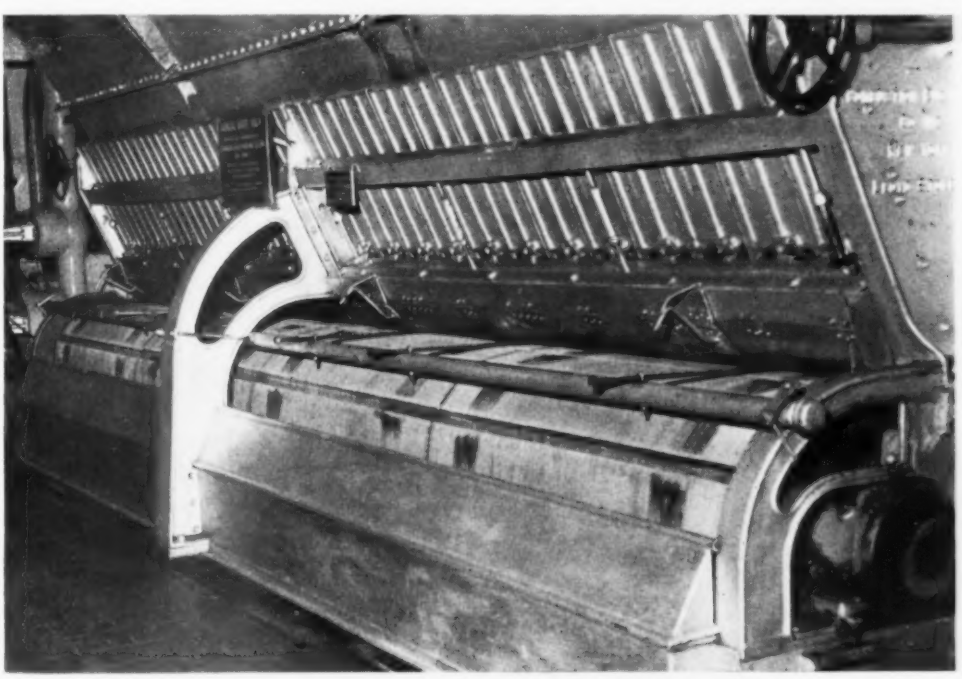


Fig. 1—Stoker front showing method of securing retaining rods that hold one-inch round breaker bars in position

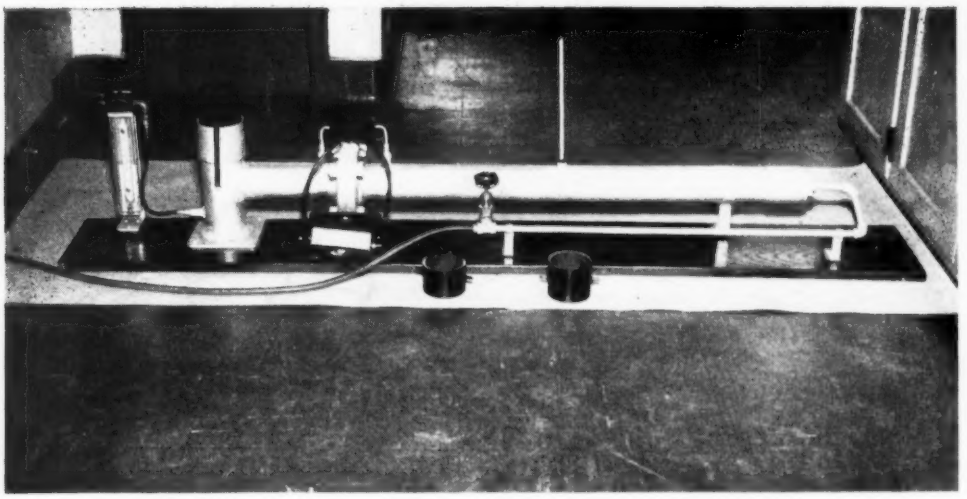


Fig. 2—Apparatus for testing coal samples for resistance to air penetration

stoker was moved the greatest distance by the screw conveyor, it was believed that the amount of superfines was increased by attrition due to the method of conveying and this was proved by sieve analysis. Some simple laboratory tests proved our theory that high undersize plus the presence of some "X" factor, presumably clay and silicates, carried over from the coal preparation process at the mines or banks resulted in an agglomeration which resisted air penetration.

Sample Testing Apparatus

To permit the testing of coal samples for resistance to air penetration, the apparatus shown in Fig. 2 was designed and built. The screen-bottomed containers shown in the foreground were made in several depths to permit simulation of different thicknesses of fuel bed as used on the stokers. In making the test, a sample of "as received" coal is placed in a container of suitable depth, compressed with a standard loading, and stricken off with a straightedge. The container is then fastened in place over the plenum chamber of the test flow measuring device and the air flow adjusted until the desired "draft" through the sample is indicated by the manometer on the left. Flow differential is then read across the metering orifice by means of the inclined draft gage. Measurements of temperature and of barometric pressure complete the data necessary for flow computation.

If desired, the loaded sample container may be "baked" as described below, before measurements of air flow are made thereon.

We also developed what we called the "muffin test." Several ordinary muffin tins were procured. Each compartment was filled with a different sample of coal. The samples were slightly and uniformly compressed to simulate the condition of green coal spread on the stoker grate. These samples were then baked in a drying oven at approximately 300 F for about one hour, after which they were allowed to cool and were tested for resistance to penetration by means of the simple device shown in Fig. 3.

The $^{5}/_{16}$-in. dowel rod (cut to form a right cylinder) was gently lowered until its bottom end rested upon the surface of the "muffin." The rod was then incrementally weight loaded until the surface of the "muffin" was penetrated in a sharp "break through." Force in grams required to cause this penetration was recorded as a measure of the low temperature caking tendency of the coal.

It was found that a sample caked by baking and then agitated would not again cake when subjected to further heating.

The quantitative measurements of air flow and of caking, described above, when correlated with tests of moisture and sizing (including per cent through 100 and 325 mesh) enabled us to predict which coals would burn without excessive carryover and/or loss of load on the stokers and thus aided in the selection of more suitable coal sources and in the rejection of some grossly unsuitable coal received from time to time.

Fig. 3—Setup for conducting the muffin test of coal samples

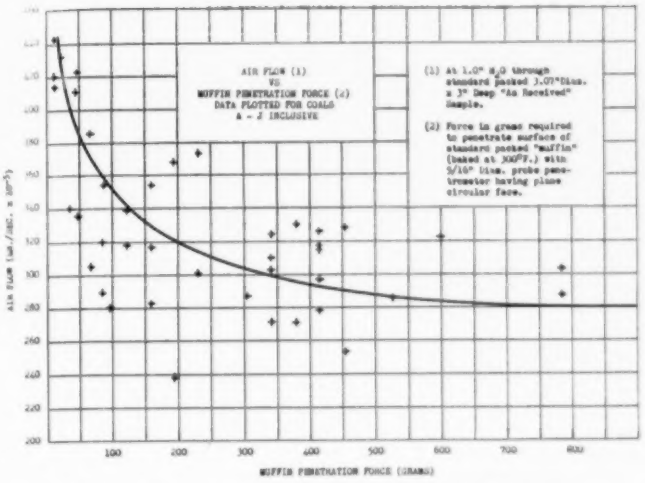

AIR FLOW (1)
VS
MUFFIN PENETRATION FORCE (2)
DATA PLOTTED FOR COALS
A - J INCLUSIVE
(1) At 1.0" H2O through standard packed 3.07"Dia. x 3" Deep "As Received" Sample.
(2) Force in grams required to penetrate surface of standard packed "muffin" (baked at 300°F.) with 5/16" Dia. probe penetrometer having plane circular face.
AIR FLOW (LBS./SEC. x 10⁻³)
MUFFIN PENETRATION FORCE (GRAMS)

Fig. 4—Results of muffin test plotted against penetration and air flow

Fig. 4 plotted with "muffin penetration" as abscissae and air flow as ordinates was obtained from tests of several fuels furnished by each of ten suppliers.

It has been found that with muffin penetration in the range of 12 to 50 grams and air flow of 400 plus that the fuel will perform excellently. Muffin penetration may increase to 100 grams and air flow may decrease to 300 to 350 with fair to satisfactory results. Higher muffin penetration than 150 and air flows below 275 have, in general, shown unsatisfactory operating results.

Mechanical Agitation

The "muffin" test described above simulated the conditions at the front of the fuel bed where radiant heat immediately starts baking the coal as it moves forward under the gate. The problem then became one of finding some mechanical means of agitating the fuel after it had been subjected to some heat on the stoker. After discarding several suggestions, a very simple device shown in Fig. 5. was installed. This consisted of three 1-in. round carbon steel bars arranged over the width of the stoker, each retained by two adjustable holding rods extending to the front of the stoker which permitted the breaker bar to be moved to the optimum position.

The bars lie directly in contact with the grate and receive sufficient air cooling to prevent warping or oxidation. Their normal life is six months. In our particular installation we found that the best results were obtained with the bar located between the second and third zone. As the grate moves toward the ash pit the fuel must cascade over the bar. This cascading action produces the stirring motion required after the preliminary bake.

This device has proved very effective. We have not experienced any drop off in load due to variation in fuels since its installation. Our experiments indicate that with clean coal of proper sizing, the use of this bar will not improve capacity; however it is most effective when the undersize is high and clay and possible silicates from the wash water are present.

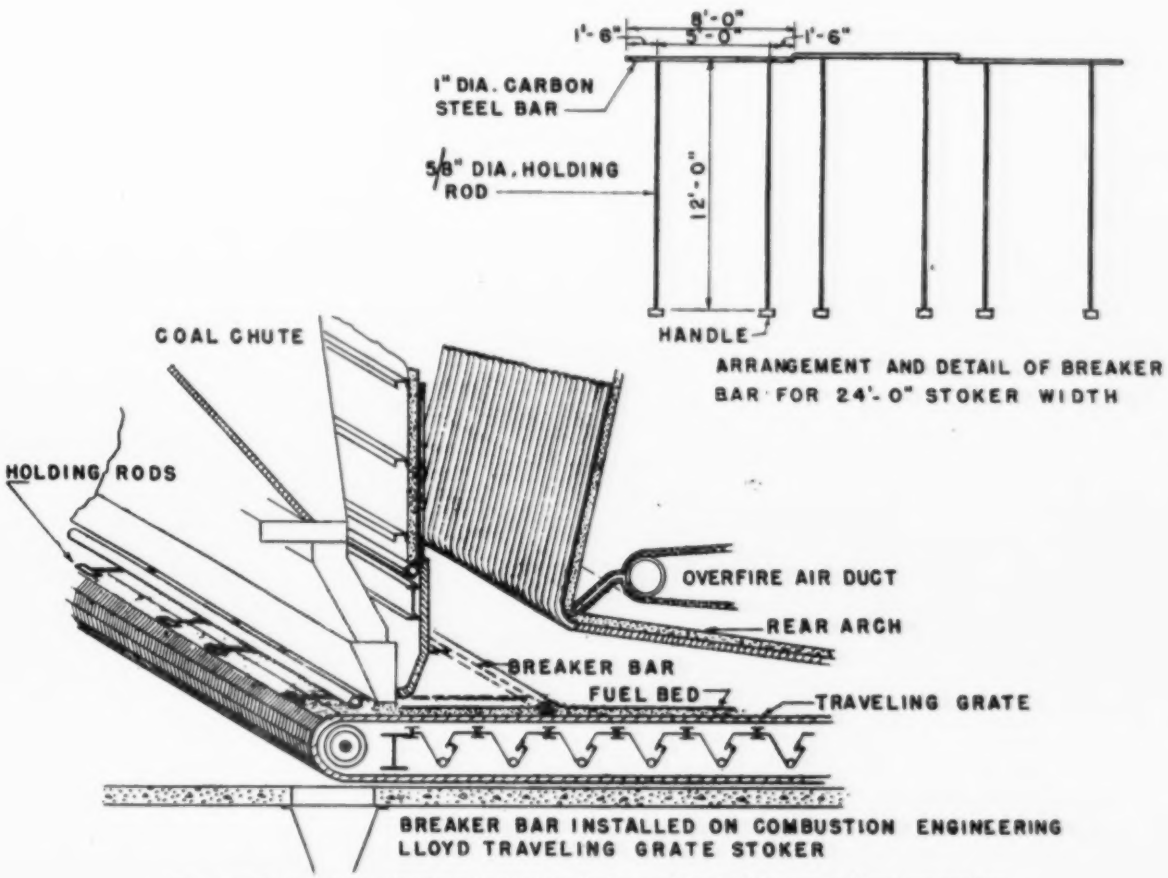


Fig. 5—Device for agitating fuel after being subjected to some heat on stoker

Influence of Low-Quality Coal on Pulverized-Fuel-Fired Units

By OTTO DE LORENZI

Combustion Engineering-Superheater, Inc.

A review of methods of steam temperature control over wide load range when burning high-ash bituminous coals having relatively low ash-softening temperatures in large high-pressure, high-temperature steam generating units; from a paper at the ASME Fall Meeting, Chicago, Sept. 8-11, 1952

Coal quality is governed, to a large extent, by sulfur and ash content, as well as ash-softening temperature. There is, however, no well-defined line separating so-called low-quality coal from high-quality.

Principal characteristic features of modern pulverized-fuel-fired units have been developed through a process of evolution, based on a wide variation in fuel quality and on many different installations. Thus after an evaluation of plant operating conditions, the designer must choose a combination of features which will assure satisfactory and trouble-free operation with the lowest quality coal that it may be necessary to burn at some future date.

The correct approach to the design of any large steam-generating unit is to employ, whenever possible, a combination of volume and watercooling which will result in a furnace outlet temperature below the ash-fusion temperature of the lowest quality fuel it may be necessary to use. Thus with coals having a high percentage of low-fusion ash, large furnace volumes are used, with correspondingly low heat-liberation rates, and of maximum water-wall surface, thereby assuring a comparatively low gas temperature at the boiler entrance. This gas temperature, however, must be sufficiently high at the minimum control point to provide the desired steam temperature.

Control of Furnace Temperature to Compensate for Sintering

The condition of furnace walls has a pronounced effect on furnace outlet temperature. If they are clean, the gas may be 200 deg F, or more, lower than when the walls are dirty. The actual range of exit temperature will vary with the coal and load conditions; also with the method of firing.

During operation, furnace walls gradually become coated with powdery ash deposits that act as a barrier to heat transfer and thereby cause an increase in furnace outlet temperature. As gradual build-up continues these deposits are eventually sintered and, unless the walls are cleaned, there is an acceleration in temperature rise which may eventually produce slagging. Therefore, it is necessary to provide some effective means for regulating furnace outlet temperature so that superheat may be maintained at a safe level.

The first steps taken to overcome difficulties resulting from the downward trend in coal quality was to reduce materially furnace heat-liberation rates; also to completely watercool all wall areas. The front boiler bank was modified so that spacings between adjacent tubes, as well as tube rows, were increased, thereby reducing entering gas velocity and making for more accessibility. The effect of this change was to lower furnace outlet temperature and minimize accumulation of fireside deposits to a point where periods between scheduled outages were of reasonably long duration. About this time there was an insistent demand to maintain constant steam temperature over increasingly wider capacity ranges. Superheater bypass dampers, desuperheaters, or controlled furnace temperature variation, either separately or in various combinations, were the means available for meeting this demand.

The amount of superheater surface and its location is usually fixed by the steam temperature required at some specific capacity, and by the fuel used. The performance of any superheater at capacity points other than that for which it is designed, will depend on a number of factors, among which are temperature and mass flow of gas sweeping over its surface. Contour of the capacity-temperature curve established for a given unit can only be shifted upward or downward by changing either the amount of gas flowing over the superheater or the entering gas temperature.

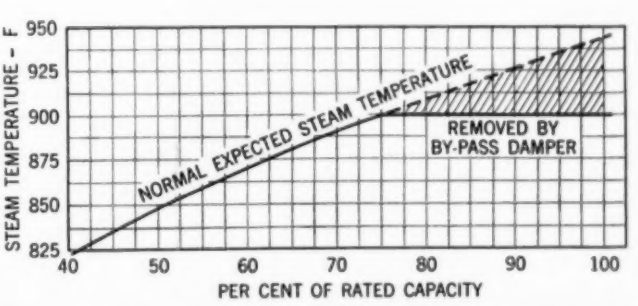


Fig. 1—Typical superheater performance characteristics with bypass damper control

One means for securing a change in gas flow is through some form of bypass. The amount of gas which can be reasonably shunted around the superheater at full load is approximately 25 per cent. Gas temperature at the furnace outlet rises with increased firing rate. Under these conditions it is possible to proportion the super-

heater surface so that design steam temperature can be maintained at a constant level through a gradual increase in bypass opening. Typical performance characteristics of a superheater with controlled gas bypass arrangement is illustrated by Fig. 1. The dash-line extension shows the point to which steam temperature will rise if the damper remains fully closed above 75 per cent capacity.

Desuperheaters of the direct-contact or noncontact type are used in some installations for controlling steam

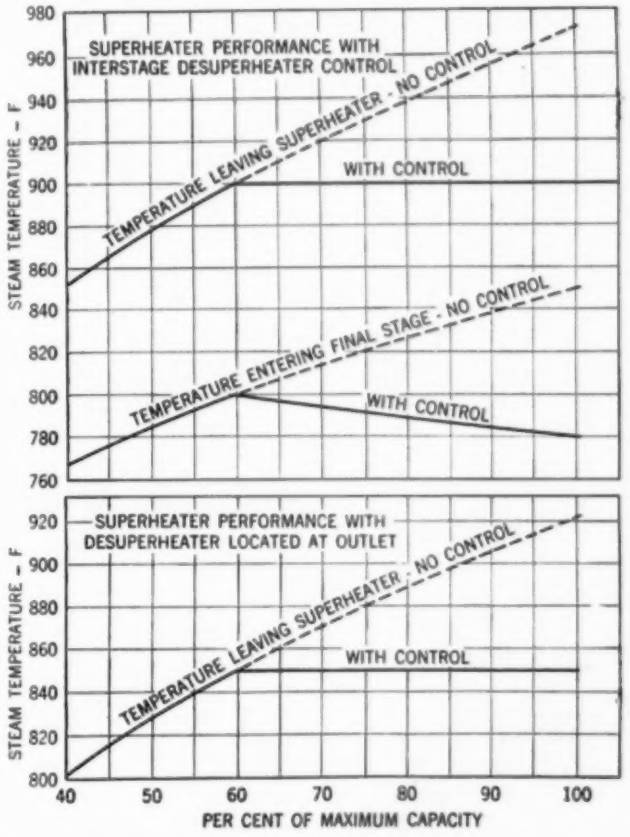


Fig. 2—Chart showing superheater performance with desuperheater control

temperature. The superheater surface is proportioned for the steam temperature required at lowest point of the control range. The capacity range over which desuperheaters are most effective will be determined by their location in the superheating circuit, and by the type employed. Most frequently encountered is the direct-contact type in which water is sprayed into the steam. Preferred location when final steam temperature is above 850 F, is between the primary and secondary stages of the superheater. With this arrangement the steam is raised to some intermediate temperature, as determined by capacity. It is then passed through the desuperheater into which an automatically controlled quantity of water is sprayed to reduce its temperature sufficiently so that, after continuing through the secondary superheating stage, the required temperature is maintained at the outlet.

With desuperheaters of this type there is an ever-present possibility of moisture carryover into the final superheating stage if the quantity of spray water exceeds some nominal value. This carryover may result in internal deposits which eventually impair operation. Typical performance curves of units with the desuperheater located inter-stage and also at the superheater outlet are shown in Fig. 2.

Differential Firing

The earlier designs employing bypass dampers and desuperheaters operated successfully over moderate capacity ranges. The desire, however, to further extend this range made it necessary to use either excessively large superheaters or higher entering gas temperature. The first was uneconomical because of greatly increased cost; the second because of reduced in-service availability owing to increased fireside slag deposits on furnace walls and parts of the boiler surface and superheater. One solution, therefore, was to use the principle of differential firing wherein, as capacity decreases, an increasingly greater proportion of the fuel is burned in the upper furnace zone.

Several installations were made employing horizontal turbulent burners installed in two or three relatively widespaced rows at different levels. Normally, all burners are kept in operation, but during low-load operation the upper row only is used to maintain a reasonably high furnace outlet temperature.

Experience, from the operator's standpoint, with the designs employing the widespaced burner rows, has fallen below expectations. The extent of furnace temperature control obtainable is quite limited, because the burners are fixed and the flame body cannot be moved about to any great extent.

Gas Recirculation

Two of the principal factors entering into superheater design and performance are inlet gas temperature and mass flow. These are fixed by operating conditions. By suitably changing the relation of gas temperature to gas flow at a given capacity, it is possible still to obtain the same steam temperature. Thus the design of superheater for a specific steam temperature, with a given gas temperature and flow, will also produce the same steam temperature with a lesser flow and higher temperature of gas, or with a greater flow and lower temperature of gas. The application of this principle, through the use of gas recirculation, provides a means for controlling both superheater performance and gas temperature at the furnace outlet.

In employing gas recirculation, varying percentages of flue gas are withdrawn from the unit at some point between boiler and air-heater outlet, and then reinjected into the furnace. Effectiveness, as a means for maintaining constant steam temperature with varying load and in extending control over a wide capacity depends on the location and manner of introducing the recirculated gas. Gas introduced at the entrance to the superheater will have but little effect on performance because it serves only to increase gas quantity and lower its temperature by dilution. But when gas is introduced so as to affect heat absorption of waterwalls or rate of combustion, it has a decided effect on furnace and superheater performance. Thus, with proper application of the gas recirculation principle, it is possible to provide designs in which furnace outlet temperature, at maximum output, is sufficiently low to avoid excessive slag deposits, even with low-quality coal, and yet maintain constant steam temperature over a wide capacity range.

The superheater design is more economical because it is based on maximum output conditions instead of for full temperature at some fractional capacity point. It should be remembered, however, that the application of gas recirculation will adversely affect performance, because both draft loss and exit gas temperature are increased as a result of higher gas flow through at least a part of the unit. The magnitude of this effect will depend on the quantity and temperature of the gas, the point of reinjection, power required by the fan for gas recirculation, and power increase for the induced-draft fan. The cumulative effect of these adverse factors is usually of an increasing order with decreasing capacity on a given unit.

Tilting Burners

Furnace outlet temperature is a function of heat absorption by the waterwalls, as well as rate of heat liberation. Heat absorption by the walls varies with their cleanliness, as well as with extent of area subjected to direct radiation and convection transfer. Thus, to secure the required temperature of gas at the furnace outlet over a range in output, it is necessary to make a relative change in both furnace volume and area of heat-absorbing surface. Inasmuch as the furnace is a rigid structure, these changes cannot be made by continuously varying its proportions. Requirements, however, can best be approached through the use of a tangentially fired furnace with vertically adjustable burners, because the radiation and convection transfer, due to sweeping action of the flame envelope over the wall surface, is greater than with any other type of firing. With this design burner assemblies are installed in the four corners of the furnace. Each assembly comprises a secondary-air compartment, complete with fuel nozzles and air guide vanes that may be tilted upward or downward as much as 30 deg from horizontal. The fuel-burning pattern can thus be continuously and quickly raised, lowered, or held stationary in the furnace cavity, as required by operating conditions.

Regulation of furnace outlet temperature is accomplished through changes in burner-nozzle tilt. Thus, by directing the incandescent turbulent mass of burning fuel toward the upper zone of the furnace, resulting outlet temperature will be higher during light load or when the walls are clean. For heavy loads, or when the walls are coated with sintered dust, increasing proportions of the entire furnace volume can be used to maintain desired outlet temperature by tilting the burner nozzles downward as required.

The effectiveness of tilting burners in regulating furnace outlet temperature is illustrated by the curves in Fig. 3. Basic data for these curves were recorded during a series of tests conducted on a large unit installed in a utility plant. The fully water-cooled furnace is of the hopper-bottom type, and burners can be tilted from 30 deg below horizontal to 30 deg above. Furnace outlet temperature can be varied over a constant range of approximately 250 deg F from 100 per cent capacity down to well below 40 per cent. It will be noted that the major portion of control is obtained above the horizontal burner position. The superheaters are proportioned for steam temperature at maximum continuous capacity with the burners in horizontal position. Temperature regulation between horizontal and full downward tilt, available at maximum design capacity, may be used to compensate for any effect of sintered dust on the walls and thereby provide an operating safety margin. Steam temperature may thus be maintained at a constant level over more than 50 percent change in capacity, without resorting to use of bypass dampers or desuperheaters. The range of tilting burners, when necessary, may be further extended through the supplemental use of gas recirculation.

With fixed burners the superheater will be oversize because it must be proportioned for design temperature at the minimum control point. Then as load is increased, furnace outlet temperature will be raised approximately 300 deg F or more when the capacity design point is reached. This increase in furnace outlet temperature will be sufficient, in most installations, to cause serious slagging of any sintered dust deposits. Furthermore, bypass dampers or a desuperheater must be in service whenever minimum control-point capacity is exceeded.

Ratio of wall area to volume, A/V, is the principal governing factor in furnace design for all units and especially so when capacity exceeds 1,000,000 lb of steam per

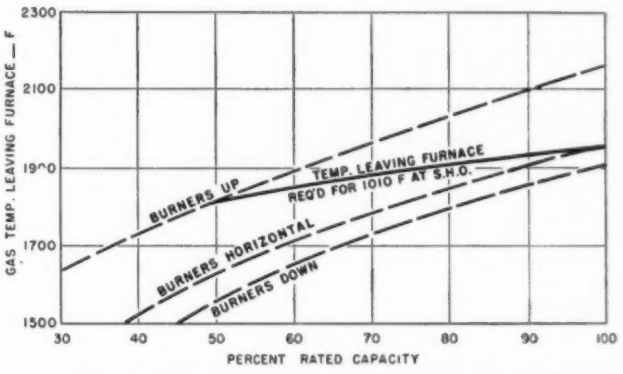


Fig. 3—Chart illustrating effect of burner tilt on furnace outlet temperature over a capacity range

hour. The influence of this factor on furnace outlet temperature with size increase has made it necessary to provide greater and greater areas of furnace-cooling surfaces, in the form of platens, dividing walls, and even multiple furnace construction, to keep below the point of sintering or slagging of dust deposits.

In the majority of larger postwar units, both non-reheat and reheat types, where design pressures are above 1200 psig and steam temperatures over 925 F, the entire saturated steam production is completed in the water-cooled furnace. This factor, in addition to the A/V ratio, definitely controls furnace outlet temperature. For a given set of conditions, which include evaporation, pressure, steam temperature, entering feedwater temperature, excess air, and efficiency, it is necessary to liberate a definite quantity of heat in the furnace. If under these conditions, all saturated steam is generated in the furnace-cooling surfaces, then the heat which remains in the gas at the furnace outlet will represent a specific temperature regardless of any mathematical gymnastics to prove otherwise. Now if the foregoing conditions remain the same but the design is modified so that part of, or additional evaporation, must be carried out beyond the furnace outlet because some form of desuperheater or convection surface is used, it follows that the furnace outlet temperature will be higher. Because of this it is

essential, particularly with low-quality coals, to keep the amount of desuperheating effect to a minimum.

Fig. 4 is a comparison of heat absorption between two units, one using burner tilt and the other fixed burners with a desuperheater. Each unit has a capacity of 600,000 lb of steam per hour at 1300 psig and 950 F with feedwater entering the economizer at 430 F and leaving at 575 F. Under these conditions the total input is 634,500,000 Btu per hr. Where burner tilt is used, all saturated steam is produced by the furnace waterwalls, and their corresponding absorption is 358,000,000 Btu per hr. The total heat added by the superheater is 172,000 Btu per hr. The unit equipped with a desuperheater is assumed to use 15 per cent of the feedwater, at rated capacity, to provide steam temperature control, even though in most cases 20 per cent is a more representative figure. Inasmuch as 85 per cent of the total saturated steam is now produced by the waterwalls, the furnace heat absorption is lowered to 304,000,000 Btu per hr. The additional heat required for total evaporation, 69, 500,000 Btu per hr, is then added to the spray water in the superheater. Thus the total heat added by the superheater now becomes 241,500,000 Btu per hour. Obviously this reduction in furnace absorption means that the furnace outlet temperature must be higher because of the greater heat content of the gas entering the superheater zone.

The unit shown in Fig. 5 is now under construction at the Meramec Power Station of the Union Electric Company of Missouri. It is of the reheat type and designed for a capacity of 925,000 lb of steam per hour when burning a low-quality midwestern bituminous coal with an ash-fusion temperature of 2100 F. The conditions of 1400 psig and constant primary and reheat temperatures of 950 F, from 925,000 down to 420,000 lb of steam per hour, were established after a detailed study of furnace outlet temperature performance which would minimize

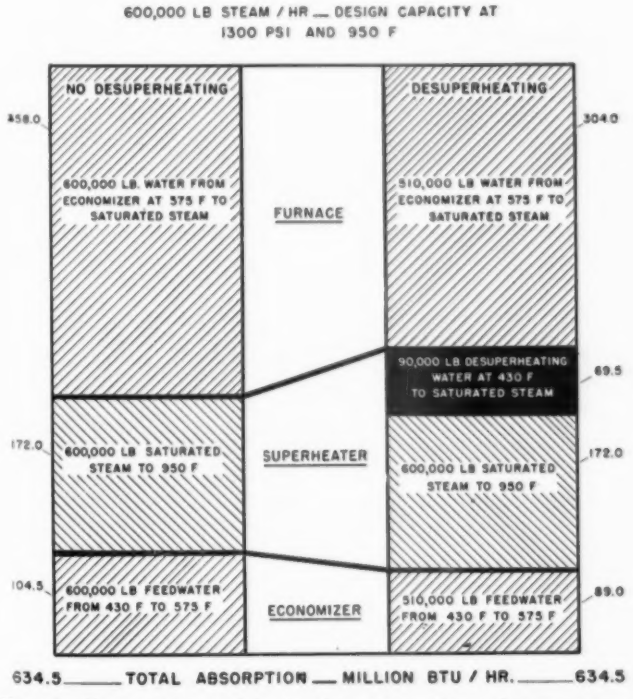

600,000 LB STEAM / HR — DESIGN CAPACITY AT 1300 PSI AND 950 F
NO DESUPERHEATING
DESUPERHEATING
458.0
304.0
600,000 LB WATER FROM ECONOMIZER AT 575 F TO SATURATED STEAM
FURNACE
510,000 LB WATER FROM ECONOMIZER AT 575 F TO SATURATED STEAM
90,000 LB DESUPERHEATING WATER AT 430 F TO SATURATED STEAM
69.5
172.0
600,000 LB SATURATED STEAM TO 950 F
SUPERHEATER
600,000 LB SATURATED STEAM TO 950 F
172.0
104.5
600,000 LB FEEDWATER FROM 430 F TO 575 F
ECONOMIZER
510,000 LB FEEDWATER FROM 430 F TO 575 F
89.0
634.5 TOTAL ABSORPTION — MILLION BTU / HR. 634.5

Fig. 4—Comparison of heat absorption for a large steam-generating unit with and without desuperheater

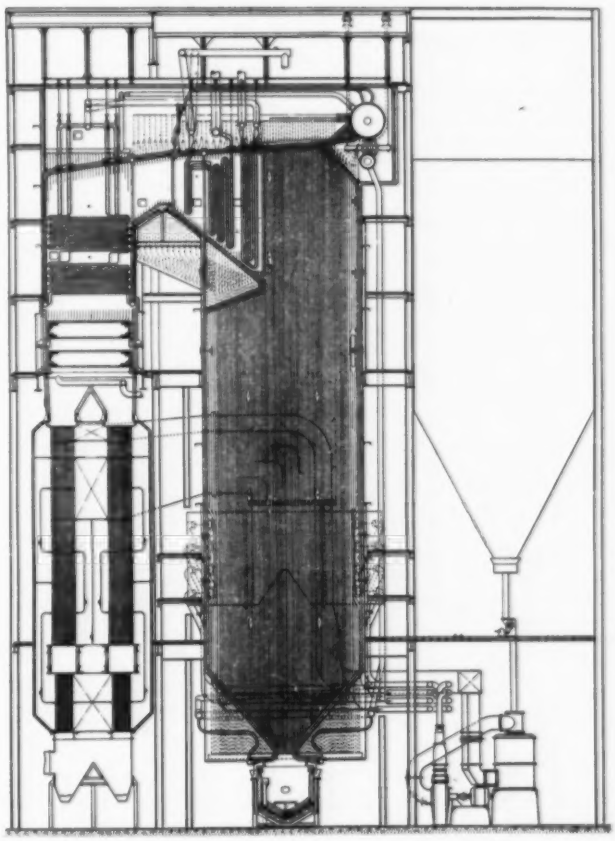


Fig. 5—One of two large steam-generating units now under construction for the Union Electric Co. of Missouri in the Meramec Power Station

sinter or slag deposits and permit long in-service operation. The completely watercooled, hopper-bottom furnace has a gross volume of 96,000 cu ft. Tangential burners of the tilting type are used, and furnace outlet temperature at design capacity is approximately 2000 F with a corresponding heat-release rate of 12,800 Btu per cu ft per hr. At the minimum control point furnace temperature is 1740 F with full upward burner tilt.

In the case of reheat units the reheat steam temperature is controlled by burner tilt,[1] which is governed in turn by the load carried, or by furnace cleanliness. Heating surfaces of superheater and reheater are, however, proportioned to require the same furnace temperature at full load. Inasmuch as the primary superheater does not have the same temperature characteristics as the reheater, it is necessary to provide up to 2 or 3 per cent desuperheating spray water, as supplementary control, to limit temperature of the high-pressure steam at reduced load.

In the Meramec unit the superheater is divided into two banks. The primary or low-temperature stage is arranged in a series of horizontal loops installed in the gas pass immediately above the economizer. The secondary or high-temperature stage comprises a vertical bank with elements spaced on wide centers and located behind a row of widely spaced furnace tubes at the furnace outlet. The reheater section, which also consists of vertical elements on somewhat closer centers, is located inter-stage between the two superheater banks.

[1] Vogel and Powell—"A Progress Report of Reheat Boiler Operation and Design"; ASME Annual Meeting, Atlantic City, 1951.

The effectiveness of tilting burners as a means for controlling steam temperatures over wide capacity variations is illustrated by the charts in Fig. 6. The unit on which these were obtained has a fully water-cooled furnace of the hopper-bottom type with a design capacity of 650,000 lb of steam per hour at 875 psig and 900 F. The guaranteed control range is from 700,000 to 435,000 lb per hr at 900 F, using both tilting burners and bypass dampers. The charts, however, were taken during a 24-hour period with bypass damper blocked shut and therefore represent tilting burner operation. Steam flow varied from 110,000 lb per hr at 3:00 am to 600,000 lb per hr from 7:00 to 8:20 pm, with corresponding steam temperatures of 890 F and 900 F. Some of the load changes were almost instantaneous, and the tilting burners were quickly adjusted automatically by steam temperature changes, so that the maximum variation fell within the plus or minus 10 deg F range.

Boiler and Superheater Tube Spacing

It was previously stated that fireside fouling of convection heat-absorbing surfaces in boiler and superheater sections results in lowered output of steam generating units. With earlier designs the solution for overcoming this difficulty was first to provide a so-called slag-screen arrangement, by widening the space between adjacent tubes of the boiler bank preceding the superheater, and then to increase furnace volume and water-cooling, thereby lowering furnace outlet temperature.

Design velocity at the superheater entrance during this period was approximately 130 fps. As coal quality was lowered, however, temperature drop through the slag screen was insufficient to prevent sintered ash from building up between the closely spaced superheater surface and then extending forward into the front boiler section. Removal of these deposits was not easily accomplished, even though conventional soot blowers were supplemented with steam, air, or water lances.

The next step came with units employing a combination of differential firing and bypass damper control. These units are usually kept in service for twelve months between scheduled inspection and maintenance periods. Furnace-wall blowers are used on a twelve-hour schedule. Boiler and superheater soot blowers are operated on an eight-hour schedule. Notwithstanding the fact that ash-fusion temperature rarely exceeds 2000 F, there has been no difficulty in keeping fireside deposits from accumulating to the extent that they would interfere with steam output.

To further improve operating conditions for slag-tap furnace applications using low-quality coal, provisions were made for easy access to all sections of the units to permit hand lancing. Space between tubes, as well as tube banks of both boiler and superheater, was increased so as to further lower gas velocity. Soot blowing systems were also expanded to include the then recently developed retractable blower for use in the furnace as well as other high temperature zones of the unit.

A design incorporating most of these features is shown in Fig. 7. This unit is one of two installed in the Calumet Station for the Commonwealth Edison Co. Design capacity is 600,000 lb per hour at 1325 psig and 935 F. The fully watercooled, continuous-slag-tap furnace has a double bank of tilting burners. Supplementary bypass dampers are used in conjunction with these burners to maintain constant steam temperature down to 450,000 lb per hour. Low-quality Illinois coal with 12.40 per cent ash, 4.70 per cent sulfur, and an ash-fusion temperature of 1980 F to 2000 F, is used. Heat liberation rate at design capacity is 18,100 Btu per cu ft per hr and the corresponding furnace outlet temperature is approximately 2000 F. Gas velocity at entrance to the superheater is 31 fps. These two units have been in commercial operation since 1947 and are usually scheduled for a major inspection and overhaul period of two weeks every twelve months. Recently one of the units, however, was maintained in service for a nineteen-month period, except for several minor outages of short duration. Furnace-wall blowers are operated once each shift. Retractable blowers in the lower superheater section are used once during each morning and afternoon shift. Boiler and economizer blowers are used during night shift only.

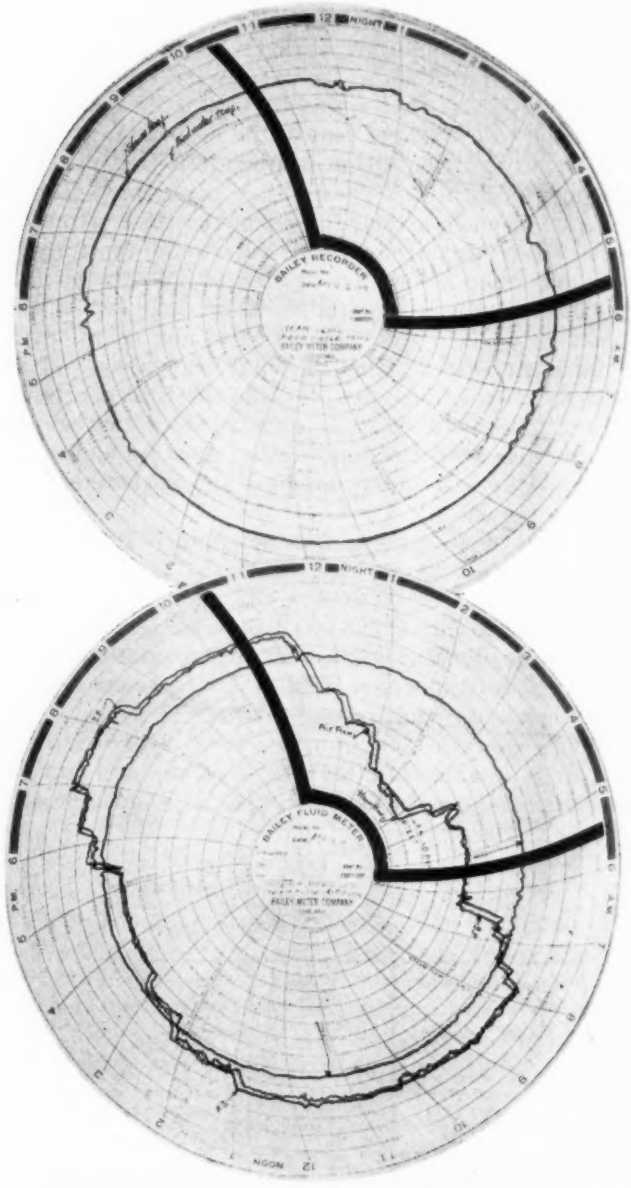


Fig. 6—Charts showing performance of a steam-generating unit using tilting burners only to maintain constant steam temperature over a wide variation in capacity

Thirteenth Annual Water Conference

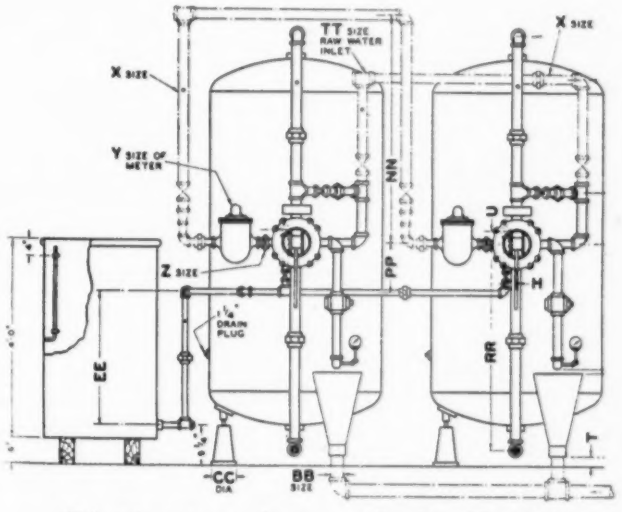
AN enthusiastic audience of more than 400 chemists and engineers was in attendance for sessions of the Thirteenth Annual Water Conference sponsored by the Engineers' Society of Western Pennsylvania and held at the Hotel William Penn, Pittsburgh, Pa., October 20–22.[1] One of the highlights of the three-day meeting was a panel discussion on cooling-tower water-treatment problems conducted by users of cooling towers and water consultants.

Chloride Anion Exchangers

Starting off the meeting was a paper by **S. B. Applebaum** of the Cochrane Corporation entitled "Experiences with Chloride Anion Exchangers for Reducing Alkalinity without Acid." In many plants, condensate-return-line corrosion caused by the carbonic acid liberated by decomposition of bicarbonate alkalinity in the boiler presents a serious problem. Three methods have generally been used in the past to reduce alkalinity, namely:

1. Use of lime in either hot or cold process to react with the bicarbonates to precipitate calcium carbonate and magnesium hydroxide.
2. Addition of sulfuric acid, which reacts with the bicarbonates to form sulfates and carbonic acid.
3. Use of hydrogen zeolite (a cation-exchanger regenerated with acid) to convert the bicarbonates to carbonic acid.

The new process employs the strongly basic anion resins, using sodium chloride for regeneration. These resins are converted to the chloride form and can split salts and exchange their chlorides for the bicarbonate, sulfate and nitrate anions in the influent water. With waters having high sulfate content, the process is not economical. However, most waters which are high in bicarbonate alkalinity are low in sulfates, so that the new process is generally attractive from the viewpoint of cost.



Chloride anion exchanger at Reading Hospital

Among the advantages of the new process are these: (1) avoidance of acid storage, acid handling, and special equipment required for its use; (2) elimination of aeration for CO_2 removal; (3) avoidance of repumping because the chloride anion-exchanger can be operated under pressure.

Discussion

One of the first de-alkalizing plants employing salt as a regenerant in an anion-exchanger was installed in 1951 at the power plant of the Reading Hospital in Reading, Pa. **N. C. Stratton,** of Gilbert Associates, recounted some of the difficulties in condensate piping failures attributable to the carbon dioxide present in the feedwater, steam and condensate of this hospital.

A study of the problem by the consulting engineers resulted in the decision to augment existing water-treatment facilities with a chloride-anion exchanger. It was found that this method of alkalinity reduction involved a substantially lower initial investment than alternative methods; that its operation was similar to that of existing water-treatment equipment in the plant; that it avoided the complications and safeguards for handling acid required in other treatments; and that plant personnel were well satisfied with the installation. As an indication of the effectiveness of the salt-regenerant method, it was stated that the number of condensate-piping failures at the hospital was reduced from 15 during the 1950–51 heating season to three during the past 1951–52 heating season.

F. N. Kemmer, of the National Aluminate Corp., commented that this method of alkalinity reduction is inherently automatic and not directly dependent upon variation of feedwater quality, making it possible to obtain a water of fairly consistent alkalinity.

Along with others who discussed the paper, **M. E. Gilwood** of The Permutit Company noted that this process would be attractive to the relatively small, low-pressure power plant because it did not require an exceptionally high degree of skill for operation and avoided the complications of acid handling.

The possibility of adding a small amount of caustic soda to the regenerant solution was mentioned by **A. E. Kittredge** of the American Water Softener Co. and by others discussing the paper. The effect of caustic addition would be to increase the pH value of the process and substantially reduce the CO_2 content of the effluent. Mr. Kittredge cited the following reasons for utilizing caustic in the regeneration process:

1. Improvement in effluent quality.
2. Improvement in the net exchange capacity of the exchange material.
3. pH value of process raised sufficiently to prevent corrosion in the exchange container and related piping.
4. Process made competitive with other methods of

[1] Copies of the Proceedings, including complete papers and discussions, may be obtained for $7.50 by writing the Society office at the same Hotel.

dealkalization when the influent alkalinity is 70 per cent or more; superior in overall economy for small installations.

Deaerating Heaters

"Experiences with Application of Deaerating Heaters in Feedwater Cycles" was the title of a paper by **V. J. Calise** and **R. K. Stenard** of the Graver Water Conditioning Co. One of the interesting trends in the application of direct-contact heaters in industrial power plants is the widespread use of the deaerating heater as a scavenger for absorbing and utilizing heat in waste and exhaust steam, in condensate-flashed steam, in condensate returns from chemical process or refining operations, and in flashed steam from blowdown and in cooling water. Likewise, the demand for immediately available storage of large quantities of deaerated feedwater has resulted in designs for greater heater storage capacities and the larger and heavier structures required for supporting these heaters above boiler feed pumps.

The authors cited case studies of deaerator design and selection problems in six industrial power plants, including a Southwest chemical plant in which an effluent sub-cooling technique was employed to avoid the substantial cost in elevating the deaerating heaters to sufficient height to insure flooded boiler feed pump suction. Four methods of removing non-condensible gases from utility station deaerators when operating pressures drop below atmospheric were described.

Deionization vs. Evaporation

T. C. Hoppe and **R. A. Russell,** of Black & Veatch, consulting engineers, Kansas City, Mo., presented a paper entitled "Deionization vs. Evaporation of Hard Water Supplies for Boiler Makeup," which dealt largely with waters having total dissolved solids in excess of 500 ppm as commonly found in the Midwest. The authors reported details of an economic study made on comparative installation costs of an evaporator and a deionizer for a 60,000-kw turbine-generator having throttle inlet conditions of 1250 psig, 950 F. The unit was calculated to be capable of generating 132 kw more when operating in conjunction with a deionizer than with an evaporator. Evaluating this difference on the basis of an assumed investment construction cost of $145 per kw and a capitalization of 12½ per cent, the following comparison was made:

	Evaporator	Deionizer
Initial cost	$14,400	$9,500
Annual fixed charges @ 12½%	1,800	1,187
Annual fuel cost	1,480	Base
Annual chemical and water cost	Base	915
Annual operator labor cost	500	900
Charge for reduced turbine capability	2,400	Base
Total annual cost	6,150	3,002

A study of turbine heat rates showed a reduction from 8954 Btu per kwhr with an evaporator to 8937 Btu per kwhr with a deionizer, in addition to the increased net turbine capability in the latter case.

The authors listed the following advantages for the use of evaporators:

1. A conventional process with which power plant operators and boiler-water consultants are generally familiar; vagaries of performance are well understood.
2. Operating cost independent of variations in water analysis and chemical costs.
3. Small space requirements; no chemical storage required.

Disadvantages of Evaporators

1. Rate of makeup production dependent on plant electrical load; equipment cannot be used in advance of plant startup.
2. With bicarbonates in makeup, evaporator vapor contains carbon dioxide which must be reduced by a deaerator.
3. Periodic cracking and scale removal required for best operation unless makeup is pretreated.
4. Inefficient removal of ammonia if present in makeup.

Advantages of Deionization

1. Serves as a source of high quality water for startup of a new station and refilling of boilers after scheduled outages.
2. Operation independent of plant electrical production. Can produce high quality water at high rates, when required, to satisfy unusual demands for makeup water.
3. Quality of makeup normally better than evaporator makeup.
4. Equipment can be located without difficulty in any available space in plant. Piping connections to other plant equipment are few and simple.

Disadvatages of Deionization

1. Requires periodic shutdowns for regeneration of exchange resins. Close attention by trained operators required during regeneration.
2. Maintenance of a supply of chemicals requires some additional storage facilities. This may not be too important where a plant is operating a pretreatment process and must engage in these activities anyway.

In making these comparisons of the two processes, the authors cautioned that either type can produce unacceptable water if poorly operated.

Discussion

Operating experience with deionizing equipment preparing waters having 500 to 600 ppm dissolved solids was presented by **D. Forty** of the Public Service Company of Northern Illinois. Water quality is reported to be better at the Waukegan Station, where a 240-gpm deionizing unit has been in service since December, 1951, in conjunction with a 100,000-kw unit operating at 1800 psig, than at any of the other stations on the system which use evaporators. On a new station now in the design stage, it is planned to use a four-bed deionizing system. It was brought out by another engineer that a relatively small additional investment in automatic equipment to robotize the regeneration process would bring in an attractive economic return.

Cooling Water Treatment Using Metallic Phosphates

"Application of Metallic Phosphates to Cooling Water Treatment" was the subject of a paper by **William J. Stone** of the Deady Chemical Co., who pointed out that they had the following desirable properties:

1. Controlled solubility.
2. Increased stability to hydrolysis and reversion.
3. Desirable cathodic and anodic properties to aid in minimizing corrosion.
4. Controlled toxicity.

The speaker was of the opinion that it is impossible to treat all sections of a cooling-water system equally well and that it is therefore desirable to concentrate efforts in the most critical sections. He anticipated the probability of sections in which the water would either have (1) corrosive properties or (2) a tendency to lay down scale. Through the employment of an extension of the Langelier index to apply to cooling waters and by increasing the pH range of the water, the technique integrates the good points of several methods used in the past. To the metallic phosphates was ascribed a "fly wheel effect" in which their composite properties meet several of the conflicting requirements of cooling water treatment.

Discussion

L. D. Betz of W. H. & L. D. Betz, water consultants, questioned whether metallic phosphate is an efficient anodic inhibitor. He advocated a more "positive" method of control avoiding some of the weaknesses of the preceding method.

Metallic phosphates, it was pointed out by **M. A. Enquist** of Metallic Phosphate Products Co., are fusion products of sodium phosphate and a metallic oxide, the purpose of which is to introduce a metallic ion into solution without adding an undesirable negative ion.

Panel Discussion on Cooling Towers

J. S. Hill of Esso Standard Oil Co. reported that on cooling towers at the Baton Rouge plant of his company having a replacement wood value of $1,800,000, the cost of repairs had increased from $39,000 in 1949 to $300,000 in 1951. Although none of the twenty towers has been replaced in its entirety, about every component part in one or another of them has been replaced, with mist eliminator slats and supports requiring most attention. Fungus attack was reported in eleven of the towers, its intensity varying with age. The effect of water flowing over the wood in towers is to (1) decrease cross-section and (2) to modify wood structure by supporting organisms which destroy the wood. Materials other than wood have been proposed for cooling tower use, including transite and masonite wall panels and aluminum mist eliminators. In concluding, Mr. Hill advocated simpler cooling-tower construction and increased attention to design details to permit greater ease of maintenance.

"Bacteria Growths and Their Control" was the topic of **R. S. Wise** of National Aluminate Corp., who raised the following questions:

1. What organisms cause slimes? Algae (blue green, green, diatoms), Fungae (molds, yeasts) and Bacteria (slime forming, corrosive-sulfate reducing, iron depositing, other non-troublesome types).
2. Where do the organisms come from? (*a*) Makeup water, (*b*) air, (*c*) various sources at time of construction and initial startup or following tower repairs.
3. Shall growth of organisms be inhibited or shall they be killed? If the latter, how often need this be done? Choice between inhibition or destruction dependent upon the source and rate of inoculation.
4. What chemical shall be chosen to do the job? Selected one (*a*) must be effective against organisms that are present, (*b*) be of limited toxicity when added in the required dosage, and (*c*) be capable of penetrating or dispersing slime masses.
5. Will the chemical do the job by itself, or is a supplementary chemical desirable? Dependent upon specific plant conditions.

In discussing "Depositions and Their Control in Cooling Tower Waters," **George Illig** of Hall Laboratories noted that calcium carbonate is the deposit most commonly found in cooling tower recirculating systems. Five methods of removing deposits, in general order of their historical development, are the following: (1) acid cleaning, (2) organic dispersing agents, such as tannin or lignin, (3) zeolite softening, (4) Langelier stability index, (5) threshold treatment with glassy phosphates. The accompanying tabulation summarizes the several methods of controlling calcium carbonate scale.

Material	Function
1. Acid treatment (sulfuric acid, burning sulfur, hydrochloric acid)	Neutralization of carbonate alkalinity, or reduction to point of desired posi- stability index
2. Organic dispersives (lignins and tannins generally used)	Colloidal treatment—5 to 25 ppm required to disperse precipitated calcium carbonate so as to retard accumulation of deposits
3. Zeolite softening	Reduction of calcium content
4. Lime and lime-soda softening	Reduction of calcium content and alkalinity
5. Glassy phosphate	Threshold treatment—2 ppm metaphosphate residual will stabilize a highly supersaturated solution of calcium bicarbonate and carbonate

J. F. Wilkes of Dearborn Chemical Company noted that control methods selected for correction of other water treatment problems often may contribute to corrosion in the absence of careful application and regulation. Among the factors influencing the selection of corrosion control methods are water supply characteristics, operating temperatures, plant location and extent of atmospheric contamination, equipment design, treatment economics, waste disposal problems, capabilities of operating personnel and supervision, and necessity for water re-use. Corrosion may occur in any or all metal components of cooling towers. Procedures developed for water treatment in one type of cooling system may be totally unsuited for use in other systems.

The chief cause of corrosion is the dissolved oxygen present in cooling water, which reacts rapidly with metals in the absence of a protective film. Although the protective oxide film on ferrous metals normally is self-healing, it is easily penetrated by ions, and if those ions react with metal below the oxide film to form a soluble salt, the

film may become undermined, exposing more metal to attack. Both chloride and sulfate ions may contribute to film breakdown.

Atmospheric contamination, continued Mr. Wilkes, may contribute to corrosion problems by reason of the environment and location of cooling towers having open recirculating systems. Also, many of the water supplies available for cooling system makeup may be found to have aggressive characteristics when evaluated on the basis of the Langelier saturation index. Another factor is galvanic action, wherein dissimilar metals in cooling systems make complete protection against galvanic corrosion extremely difficult. This is especially true where bimetallic contacts exist. Other ways in which corrosion takes place include inlet end and impingement attack, abrasion caused by precipitated metallic oxides, cavitation, concentration cells built up in crevices and restricted water pockets, dezincification, and improper equipment design and maintenance.

The last paper in the cooling-tower panel discussion was entitled "A Review of Testing Techniques in Cooling Tower Waters" by **J. K. Rice** of the Cyrus William Rice Company. Testing may be carried out by (1) subjecting a relatively small sample to a given environment and determining the effect of that environment upon the sample, (2) employing a sample unit having dimensionally similar properties and similar flow and surface characteristics, and (3) using full-scale units to measure the effect of environment in terms of operating difficulties and maintenance costs. An ideal to be striven for in corrosion measurement is a means for instantaneous determination of corrosion rate.

Mr. Rice reported on a new development in corrosion testing which was devised independently by researchers at the Armour Institute in Chicago and by the Cyrus William Rice organization in Pittsburgh. It employs the principle that an electrical capacitor will pass an alternating-current potential while blocking a direct-current potential. The surface of a material located in a corrosive environment contains alternate anodic and cathodic areas. If the surface is caused to move rapidly past a very small reference electrode probe, an a-c voltage will be generated in addition to and will be impressed upon the overall d-c voltage of the cell that is formed. In the instrument described, the a-c voltage is separated from the d-c voltage by a blocking capacitor, is amplified by a desired amount, and is then applied to the vertical deflection plates of a cathode ray tube. The wave thereby made visible may be interpreted in terms of peaks, which represent anodic areas, and valleys, which represent cathodic areas. The author reported finding a correlation between the observed wave forms and corrosion rates as evidenced by the usual methods of visual inspection and comparison.

Carbon Dioxide Content of Steam

Substantial verification, in the pressure range of 15 to 100 psig, of decomposition of carbon dioxide as reported in 1932 by F. G. Straub and R. F. Larson for the 150–1500 psig pressure range, was provided by **J. J. Maguire** and **R. E. Winston** of W. H. & L. D. Betz in a paper entitled "Effect of Operating Pressure on Carbon Dioxide Content of Steam." This very recent investigation disclosed that, over the lower pressure range, operating pressure and temperature have a more marked effect than at higher pressures and temperatures. Decomposition rate at 15 psig (250 F) is only half that at 100 psig (338 F), and it is a function of the partial pressure of carbon dioxide in the steam and the available carbon dioxide in the feedwater. Decomposition is independent of steaming rate, and a higher percentage is obtained with sodium carbonate than with sodium bicarbonate. By operating evaporators at the lowest pressure consistent with operating economy, it is possible to minimize the carbon dioxide content of steam and decrease the corrosion problem at the point of condensation of evaporator distillate.

Resinous Materials in Low-Pressure Boilers

An interesting case study of steps taken to solve the problem of firebox sidesheet failures in Canadian steam locomotives was reported by **W. L. Andrews** of Bird-Archer, Ltd., in a paper entitled "Control of Resinous Materials in Low-Pressure Boilers." It was found that cracks in the steel sheets were of a trans-crystalline nature, indicating their derivation from thermal stress. The author mentioned details of the laboratory investigations which were carried out to ascertain effect of overheating on metallurgical structure and to determine the nature of the deposits on the water-side of the sheets. It was found that the residual material had an extremely low specific heat. In August 1946 an organic water treatment was adapted for use, and the following year it was reported that there were no failures of side sheets or firebox syphons in the locomotives in which the difficulties previously were experienced.

Diatomite Filtration

"Removal of Oil from Condensate by Diatomite Filtration," by **G. R. Bell** of Johns-Manville Research Center, was the title of the last paper presented before the Conference. Exhaust steam from unaflow engines and high-pressure turbines may contain very stable emulsions of oil and water which are difficult to remove effectively by conventional mechanical filtration methods. There are chemical processes which will separate out the emulsified oil, but these have the disadvantage of adding salts which must later be removed from the condensate. The author reported that since 1942 there had been 80 shipboard and 70 land-based installations employing diatomite filtration and that oil removal efficiencies on the order of 0.1 ppm of oil may be realized if due precaution is observed. The effectiveness of this method of filtration increases with increasing temperature, and rust may be removed as well as oil. Because diatomite is substantially silica, there may be some objection to its use in extremely high-pressure, high-temperature installations, such as central stations. However, there are a wide variety of moderate pressure of industrial power plants employing back-pressure cycles where re-use of condensate may be made more feasible through employment of this type of filter.

Facts and Figures

The coal mining industry in the United States produces approximately a third of the world's supply.

•

It is estimated that a human being is capable of exerting, over an appreciable period, only about a tenth of a horsepower.

•

There are slightly more than 200 privately owned district heating utilities now operating in this country.

•

T.V.A.'s new Shawnee steam power plant when completed will have a rated capacity of $1^1/_2$ million kilowatts.

•

Coal was first burned in locomotives in the United States in 1831.

•

The largest steam turbine-generator now on order will have a capability of 250,000 kw.

•

For best results, the maximum furnace heat liberation with blast furnace gas will range from 20,000 to 23,000 Btu per cu ft.

•

The quantity of natural gas marketed annually in the United States has tripled in the last fifteen years, with Louisiana leading all other gas-producing states.

•

A report released during the recent Cleaner Air Week, October 20–26, shows that industry is spending approximately $120,000,000 annually on equipment to control air pollution. This is exclusive of engineering and research costs.

•

At the U. S. Bureau of Mines synthetic fuels plant in Louisiana, Mo., a ton of coal yields 126 gallons of gasoline and more than 40 gallons of other liquid fuels plus an assortment of chemicals.

•

According to an announcement of the British Electricity Authority, the average thermal efficiency of the numerous stations under its jurisdiction was 21.79 per cent for the year 1951. The best performance was that of the Dunston "B" No. 2 Station which showed 29.39 per cent.

•

Statistics issued by the Federal Power Commission show that, at the beginning of the present year, there were 300 privately owned electric utility companies operating in the United States. These accounted for 3089 generating plants of which 689 were steam. A third of these latter plants (60,000 kw and over) account for 83 per cent of the energy produced by steam.

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OPERATING RANGES

	Standard	High Pressure
MAXIMUM BHP	100	150
MAX. STEAM TEMP.	525° F	750° F
MAX. PRESSURE	275 lbs.	600 lbs.
BACK PRESSURE up to	50 lbs.	50 lbs.
SPEEDS up to	4000 RPM	4000 RPM

SPECIFICATIONS

ROTOR: All Steel
BUCKETS: Nickel Steel
NOZZLES: Bronze, Stainless Steel or Monel depending upon Steam Conditions
PULLEY DRIVE: Separate Jackshaft Coupled to Turbine
LUBRICATION: Filtered Oil or Grease
GOVERNORS: Overspeed Trip & Speed Regulating
STUFFING BOXES: Split removable, packed with semi-metallic packing
BEARING CAPS: Bearings are mounted in separate housings attached to main castings
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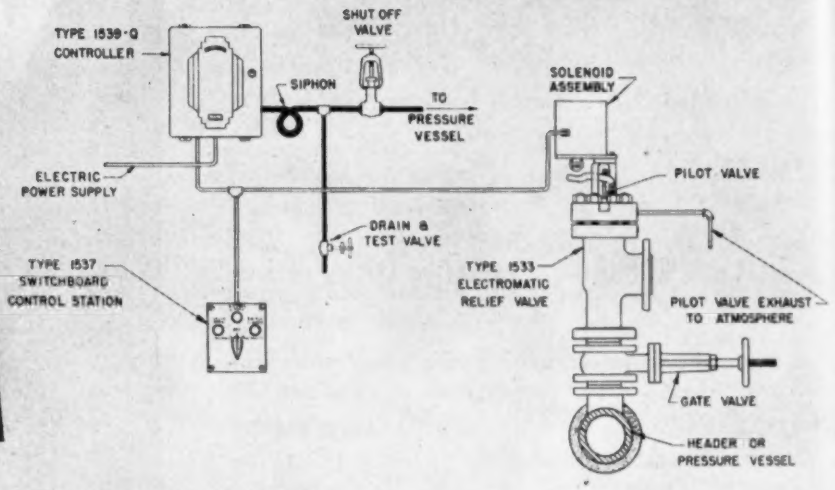

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5. Greater protection against overheating your superheater.
6. Increased efficiency for your steam generating plant.

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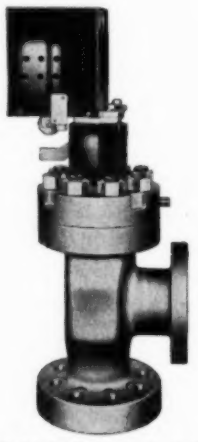

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ASME Annual Meeting Program Briefed

BUILDING for the Future of America is the theme for the 1952 Annual Meeting of The American Society of Mechanical Engineers which will be held in the Hotels Statler and McAlpin, New York, N. Y., November 30–December 5. Approximately 300 papers on a wide variety of mechanical engineering subjects will be presented during the 97 sessions sponsored by the professional divisions and committees of the society.

At the President's Luncheon on Monday, December 1, R. J. S. Pigott will have as his subject, "The ASME and the Engineer." The Management Division will sponsor a panel discussion on social and technical aspects of the automatic factory. Professional development of the engineer will be emphasized in sessions sponsored by the Education and Junior Committees.

The Roy V. Wright Lecture on citizenship responsibilities of engineers will be delivered at a Tuesday luncheon by Alfred H. Williams, president of the Federal Reserve Bank of Philadelphia, whose subject will be "Business Leadership in a Democracy."

At the Annual Banquet on Wednesday evening, Honorary Membership will be conferred upon John M. Lessells, editor of the *Journal of Applied Mechanics*, and Stephen Timoshenko, Professor of Theoretical and Applied Mechanics at Stanford University. The ASME Medal, Holley Medal, Worcester Reed Medal and Melville Medal will also be awarded at the Annual Banquet.

The following listing of papers and events is based upon the preliminary program. Since these arrangements are only tentative, persons planning to attend a specific session will find it advisable to make confirmation by contacting ASME headquarters prior to the Annual Meeting.

Items of Interest in the Power Field

Monday, December 1, 9:30 a.m.

"Vorticity Heat Transfer in Molten Metals," by R. G. Kennison, Knolls Atomic Power Laboratory.

"Report on a Liquid-Metal Heat-Transfer and Steam-Generation System for Nuclear Power Plants," by T. Trocki and D. B. Nelson, Knolls Atomic Power Laboratory.

"Design and Performance of Liquid-Metal-Heat Exchangers and Steam Generators for Nuclear Power Plants," by R. D. Brooks and A. L. Rosenblatt, Knolls Atomic Power Laboratory.

"Wood Burning," by W. L. Wagner, Detroit Stoker Co.

"Turbulence Suspension Burning of Wet Wood and Other Fuels," by Otto de Lorenzi, Combustion Engineering-Superheater, Inc.

"Wood Burning in Central Stations," by Ray B. Boals, Eugene Water & Electric Board, and Dale Bumstead and C. D. Judson, Bumstead-Woolford.

"Effect of Rotary Regenerator Performance on Gas-Turbine-Plant Performance," by D. B. Harper and W. M. Rohsenow, Massachusetts Institute of Technology.

"Rotary Regenerative Air Preheater for Gas Turbines," by A. T. Bowden and W. Hryniszak, C. A. Parsons and Co., Ltd.

Monday, Dec. 1, 2:30 p.m.

"Residual Fuel-Oil Ash Corrosion," by B. O. Buckland, C. M. Gardiner, and D. G. Sanders, General Electric Co.

"The Use of Residual Fuel Oils in Gas Turbines," by Philip Draper, Shell Petroleum Co., Ltd.

Monday, Dec. 1, 8:00 p.m.

"Air-Preheater Design as Affected by Fuel Characteristics," by W. E. Hammond and Hilmer Karlsson, The Air Preheater Corp.

"Tubular Air-Heater Problems," by George Parmakian and E. F. Rothemich, Riley Stoker Corp.

Tuesday, Dec. 2, 9:30 a.m.

"Combustion of Pulverized Coal in Water-Cooled Radiant Tubes," by R. A. Sherman, Battelle Memorial Institute, T. R. Sawyer, Steam Locomotive Research Institute, Inc., and G. E. Keinath, Battelle Memorial Institute.

"The Development of a Vaporizing Oil Burner," by J. A. Johnson and E. H. Eustis, Thermal Research & Engineering Corp.

"Pulverized-Coal Gasification—Ruhrgas Processes," by Kurt Traenckner, Essen, Germany.

"Some Considerations in the Installation of the Gas Turbine in a Closed Compartment," by L. W. Shallenberg, J. O. White Mechanical Laboratory, and K. E. Schlachter, U. S. Naval Engineering Experiment Station.

"Closed-Cycle Air-Turbine Plant," by S. T. Robinson, Sanderson & Porter.

Tuesday, Dec. 2, 1:30 p.m.

"Recent Developments and Progress in Air-Pollution Abatement," by A. D. Brandt, Bethlehem Steel Co.

"Health Aspects," by R. A. Kehoe, University of Cincinnati.

"Air Pollution Indicated by Symptoms on Vegetation," by P. W. Zimmerman, Boyce Thompson Institute.

"Some Legal Aspects of Air Pollution Abatement," by F. L. Seamans and Smith Buchanan, Ingersoll, Rodewald & Eckert.

"Stack Diffusion," by E. W. Hewson, Massachusetts Institute of Technology.

"Engineering and Management," by G. F. Jenkins, Carbide & Chemical Corp.

"Sampling and Measurement," by L. Silverman, Harvard School of Public Health.

"Industrial Experiences in Fly-Ash Collections," by B. S. Norling, E. I. du Pont de Nemours & Co., Inc.

Tuesday, Dec. 2, 8:00 p.m.

"Industrial Application of Ignition Arches for Single-Retort Stokers," by T. S. Spicer, Pennsylvania State College.

"Present-Day Thoughts on Application of Single-Retort Underfeed Stokers," by D. J. Mosshart, Westinghouse Electric Corp.

"Single-Retort Underfeed Stokers," by E. C. Webb and J. E. Atchison, Iron Fireman Manufacturing Co.

"Quick Starting of Large High-Pressure, High-Temperature Boilers," by J. C. Falkner, Consolidated Edison Co. of New York.

"Discussion of Quick Starting of Boilers," by W. H. Rowand, The Babcock & Wilcox Co.; B. J. Cross, Combustion Engineering-Superheater Inc.; and A. R. Weismantle, Foster Wheeler Corp.

"Discussion on Quick Starting of Steam Turbines," by Carl Schabtach, General Electric Co.; R. L. Reynolds, Westinghouse Electric Corp.; and C. D. Wilson, Allis-Chalmers Manufacturing Co.

Wednesday, Dec. 3, 9:30 a.m.

"Latest Practice in Europe for Planning and Operating High-Pressure Plants Equipped with Monotube Boilers," by J. Gastpar, Sulzer Brothers, Ltd.

"Design Formulas for High-Temperature, High-Pressure Piping," by F. S. G. Williams, Taylor Forge & Pipe Works.

"Energy Flow and Conversion," by N. P. Bailey, Rensselaer Polytechnic Institute.

Wednesday, Dec. 3, 2:30 p.m.

"Three-Dimensional Flow Theory of Axial-Flow Compressors," by George F. Wislicenus, Johns Hopkins University.

"Some NACA Research on Centrifugal Compressors," by A. Johnsen and

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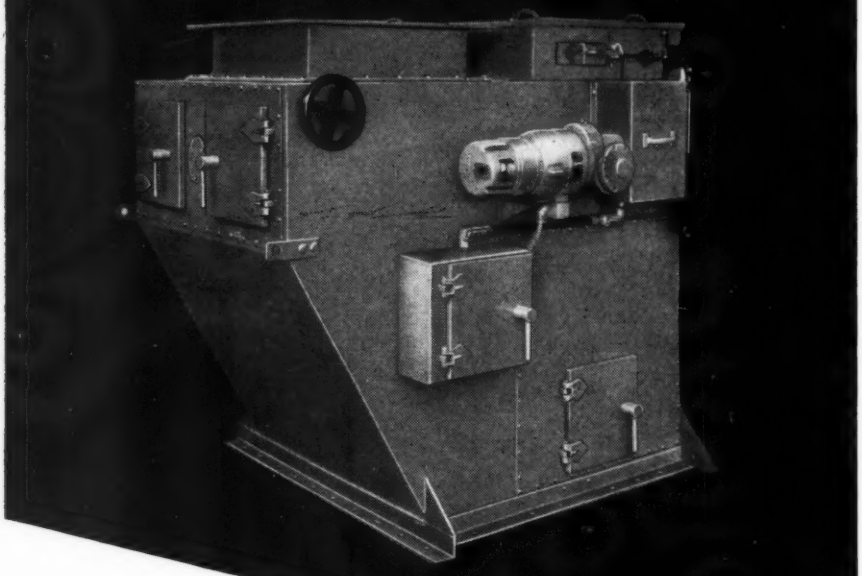

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Ambrose Ginsberg, Lewis Flight Propulsion Laboratory.

"Furnace Heat Absorption in a Spreader-Stoker-Fired Steam Generator, Part 1—Furnace Heat-Absorption Efficiency as Shown by Enthalpy of Gases Leaving the Furnace," by J. W. Myers and R. C. Corey, United States Bureau of Mines.

"Furnace Heat Absorption in a Spreader-Stoker-Fired Steam Generator, Part 2—Variation in Furnace Heat-Absorption as Shown by Measurement of Temperature of Exposed Side of Furnace Tubes," by F. G. Feeley, Jr., Union Carbide and Carbon Corp., and Earle C. Miller, Riley Stoker Corp.

"Radiant Heat Transfer Vs. Wall-to-Tube Spacing in Radiant Superheaters," by Robert Reed, John Zink Co.

"Laboratory Investigation of Superheater Tubing Materials in Contact with Synthetic Combustion Atmospheres at 1350 F," by C. J. Slunder, A. M. Hall, and J. H. Jackson, Battelle Memorial Institute.

"Resistance of Cast Fe-Cr-Ni Alloys to Corrosion in Oxidizing and Reducing Flue-Gas Atmospheres," by J. H. Jackson, C. J. Slunder, Battelle Memorial Institute; J. T. Gow, Electric Steel Foundry Co.; and O. E. Harder, Battelle Memorial Institute.

"Corrosion of Mercury Boiler Tubes During Combustion of Heavy Residual Oil," by A. M. Hall, Battelle Memorial Institute; D. Douglas, Hartford Electric Light Co.; and J. H. Jackson, Battelle Memorial Institute.

"Thermal Shock and Other Comparison Tests of Austenitic and Ferritic Steels for Main Steam Piping—A Summary Report," by W. G. Schreitz and W. C. Stewart, U. S. Naval Engineering Experiment Station.

Thursday, Dec. 4, 9:30 a.m.

"Contamination of Condensate by Heat-Exchanger Tube Alloys," by J. D. Ristroph, Virginia Electric & Power Co., and E. B. Powell, Stone & Webster Engineering Corp.

"Experimental Studies of Boiler-Tube Metal Temperatures," by C. Jacklin, National Aluminate Corp.

"Conversion of a Two-Stage Hot-Process Water Softener from Hot Lime-Soda-Phosphate to Hot Lime-Zeolite," by G. H. Gowdy, The Negea Service Corp. of the New England Gas & Electric System, and S. B. Applebaum, Cochrane Corp.

"The Venturi as a Meter for Gas-Solids Mixtures," by Leonard Farbar, University of California.

"Experimental Evaluation of Expansion Factors for Steam," by J. W. Murdock and C. J. Folz, U. S. Naval Boiler and Turbine Laboratory Naval Base.

"Recent Development in the Use of

Pellets for the Removal of Slag Deposits in Boiler Furnaces," by W. F. Cantieri, Diamond Power Specialty Corp.

"The Use of Additives to Reduce Oil-Slag Deposits," by E. C. Huge, The Babcock & Wilcox Co., and Robert B. Lee, Florida Power & Light Co.

"Thermodynamics of Turbomachines," by A. J. Stepanoff, Ingersoll-Rand Co.

"Aerodynamic Design of Efficient Two-Dimensional Channels," by J. D. Stanitz, Lewis Flight Propulsion Laboratory.

Thursday, Dec. 4, 2:30 p.m.

"Gas-Turbine Electric Locomotives on the Union Pacific," by A. H. Morey, General Electric Co., and F. Fahland, Union Pacific Railroad Co.

"Operation of Westinghouse-Baldwin Gas-Turbine Locomotive," by T. L. Weybrew, C. Kerr, Jr., and T. J. Putz, Westinghouse Electric Corp.

Thursday, Dec. 4, 8:00 p.m.

Symposium—"Industrial Power-Plant Costs": C. S. Robinson, E. I. du Pont de Nemours & Co., Inc.; T. A. Fearnside, Stone & Webster; J. Campbell, E. I. du Pont de Nemours & Co., Inc.; F. G. Feely, Jr., Carbide & Carbon Chemicals Co.

Friday, Dec. 5, 9:30 a.m.

"Development in Design of Turbine-Generator Lubrication and Control-Oil System," by George H. Newton, Westinghouse Electric Corp.

"Turbogenerator Lubricating Systems with Emphasis on Safety and Simplification," by James J. Gibney, Jr., General Electric Co.

Items of General Interest

Monday Dec. 1, 12:15 p.m., President's Luncheon

"The ASME and the Engineer," by R. J. S. Pigott.

Monday, Dec. 1, 8:00 p.m.

"Professional Development and the Young Engineer," by D. Jahncke, Ford Motor Co.

"Computing Machines and the Future of the Engineer," by Walter Pitts, Massachusetts Institute of Technology.

"Operations Research," by John B. Lathrop, Arthur D. Little, Inc.

Tuesday, Dec. 2, 12:15 p.m.—Heat Transfer Luncheon

"Problems in Heat Transfer Application," by W. E. Lobo, M. W. Kellogg Co.

Wednesday, Dec. 3, 12:15 p.m.—Roy V. Wright Luncheon and Lecture

"Business Leadership in a Democracy," by Alfred H. Williams, President, Fed. Reserve Bank, Philadelphia.

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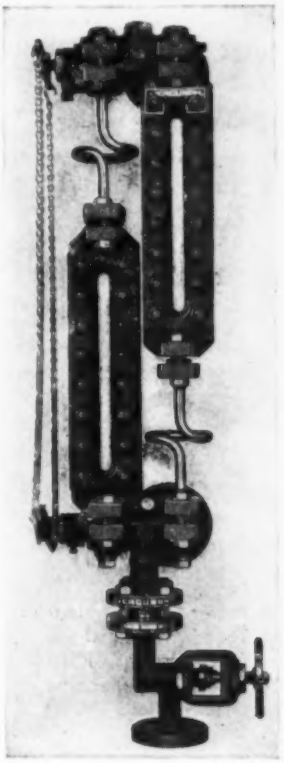
Rugged, Space-Saving Design, Expansion Coils, Other Special Features Insure Best High Temperature Performance



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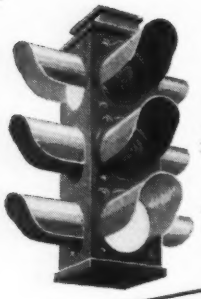

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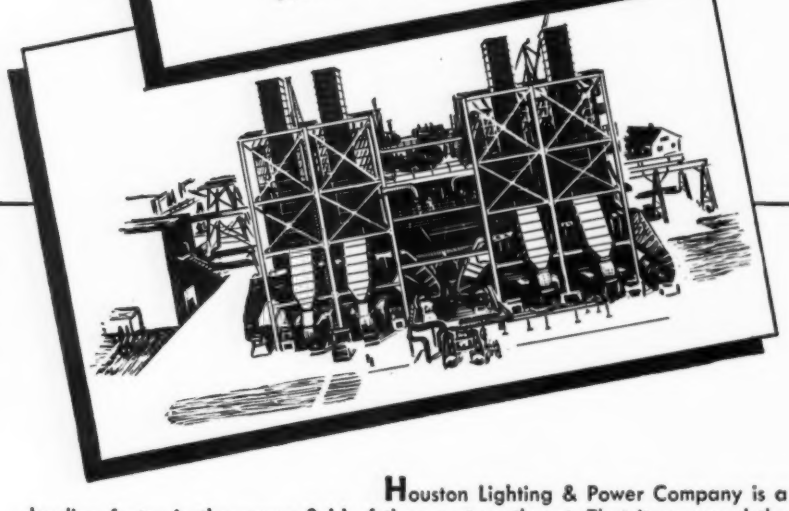

Houston Lighting & Power Company is a leading factor in the power field of the great southwest. That it approved the selection of Green Draft Fans by the boiler manufacturer — in this case Riley Stoker — is evidence of high acceptance in the field. No utility can afford to operate with inferior or unsuitable equipment at *any* point. It must have equipment that is not only highly efficient but right.

To Houston Lighting & Power can be added other well-known recently completed utilities that are Green Fan plants, among them the following:

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Atlantic City Electric Co.
Virginia Electric & Power Co.
Monongahela Power Co.
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Pacific Gas & Electric Co.
South Carolina Public Service Authority
Buffalo Niagara Electric Corp.

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Wednesday, Dec. 3, 12:15 p.m.—Fuels Division Luncheon

"Fuels in a Technical Economy," by Frederic O. Hess, President, Selas Corp.

Wednesday, Dec. 3, 12:15 p.m.—IIRD Luncheon

"Control and Communication," by Gerard Piel, Publisher, *Scientific American.*

Wednesday, Dec. 3, 2:30 p.m.

"A Theory of Decision-Making in Management," by Robert T. Livingston and David B. Hertz, Columbia University.

"The Modern Theory of Communication," by Brackway McMillan, Bell Telephone Laboratories.

Wednesday, Dec. 3, 7:30 p.m.—Annual Banquet

Address by Charles F. Kettering, General Manager of General Motors Corp. Research Laboratories.

Thursday, Dec. 4, 9:30 a.m.

"The Professional Man and His Lay Client," by C. J. Freund, University of Detroit.

"Developing Professional Consciousness in the Young Engineer in Industry," by R. E. Burton, E. I. du Pont de Nemours & Co., Inc.

Albert L. Cole

Our attention has been called to the sudden passing of Albert L. Cole, Superintendent of Power for the Saskatchewan Power Commission on September 10 while on a business trip to St. Catharines, Ontario.

A Canadian by birth and early education, Mr. Cole was well known in the United States where he spent a number of years. Beginning his engineering career with the Weston Instrument Company in Jersey City he later became successively an operating engineer and chief engineer for the Regina (Sask.) power station. He left there in the early twenties to join the editorial staff of *Power* and wrote many articles on operating subjects. Returning to Canada in 1932, he became in 1937 superintendent of the Saskatoon power plant, later assuming broadened responsibilities in 1946 as superintendent of power for the Saskatchewan Power Commission with supervision over development work and generation by that body's numerous power plants throughout the Province.

Mr. Cole was a member of the Engineering Institute of Canada and the Canadian Professional Engineers society. At the time of his death he was 63 years old.

Experience with Furnace Television

In the July 1951 issue COMBUSTION was the first to report, in an article by **L. M. Exley,** on the installation of television for direct viewing of furnace conditions at the Port Jefferson power station of the Long Island Lighting Company. Subsequent experience of more than a year has now been related by Mr. Exley in a paper at the New Orleans meeting of the AIEE on October 13–17, from which the following abstract has been made.

It will be recalled that each of the 425,000-lb per hr tangentially fired steam generators are designed for burning either coal or oil with tilting tangential burners for superheat control. The camera is mounted over a centrally located opening in the furnace roof and the picture is transmitted to a panel in the centralized control room. The lense was protected, in the first unit, by a water-cooled window mounted within a chamber supplied with compressed air, the air stream passing across the bottom glass of the window. A closed water circulating system prevented discoloration of the water side of the glass.

In the more recent installation, for the second boiler, lense protection is provided by an air-cooled window supplied with air at 1 psig from a small positive-type motor -driven blower. The camera itself is cooled and pressurized by a small low-head impeller-type fan.

While the water-cooled window afforded excellent protection and operated for three months or more without cleaning, when it did have to be cleaned complete disassembly became necessary. Therefore, the air-cooled window was developed for the second unit.

To date there have been no failures of cameras or picture tubes, and maintenance has been nominal, particularly after the electricians had become familiar with the equipment.

The screen has been observed over the full range of boiler operation with both coal and oil. Preparatory to lighting off, the ignition torches can be seen on the screen in the control room and the operator can tell at a glance if all are lighted.

In bringing a unit up to pressure on coal from a cold start, and until the turbine is phased in, the light oil burners are used. The steam atomizing torches that are used for heavy oil are also used for light oil. It has been observed that flame as seen through inspection doors at the burners may appear satisfactory with unsatisfactory combustion shown in the furnace to the extent that the stack is smoking.

In lighting off pulverized coal the screen blanks out when the fuel is first admitted to the furnace. Ignition normally takes place in about 30 sec after which the screen brightens and the flame pattern appears as ignition becomes stable.

During low-load operation on coal, ignition torches are operated continuously to maintain a stable fire, and although the light intensity on the screen is low at very light loads the picture is sufficiently clear to indicate furnace conditions.

Loss of ignition due to stoppage of oil or coal flow is shown instantly by a black screen which also indicates serious incomplete combustion. The latter is due to the fact that, since the camera is located at the top of the furnace, the unburned fuel rises and obscures the flame. In the event of lost ignition the operator must verify the condition by observing the furnace draft which always changes at loss of ignition, also by noting pulverizer instruments in the case of coal and the fuel pressure gage in the case of oil. The steam pressure gage and steam flow meter will also help; and at Port Jefferson the operator has the flame image mirror for a positive check.

While television will indicate a serious condition, other instruments must be checked and analyzed to determine the exact condition and remedy. However, it will provide preventative information to lessen the possibility of explosions and loss of ignition. Moreover, television will show instantly changes in furnace conditions that may lead to a smoking stack.

Television has also proved helpful in analyzing burner conditions. For example, before television was installed, during burner cleaning on oil firing, dark puffs were usually observed from the stack. It had been concluded that the operators were cutting the oil burners back in service too quickly. However, with installation of television it was soon learned that the dark puffs were caused by purging the burners too rapidly. With a picture of the furnace before the opera-

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tors, it was found that in burning high-volatile coal the point of ignition could be kept further away from the burners than was previously considered practical.

In conclusion Mr. Exley expressed the opinion that while television has some limitations in not being able to distinguish between thick smoke, dust clouds or an unlighted furnace, it has proved a most helpful operating aid. It is also of help in counteracting one of the disadvantages of remote centralization of steam generator instruments by giving the operator a sense of reality.

A second paper at this AIEE Session, by **G. H. Wilson** of Diamond Power Specialty Corp., dealt with the application of television, in the form of the "Utiliscope" to various industrial processes, as well as to central stations for the additional purpose of observing water level gage readings, the appearance of stack tops, etc.

Motor Drives for Pulverizer

The following observation concerning pulverizer drives was contained in a recent AIEE paper by **R. W. Ferguson** of Westinghouse Electric Corporation:

Ability of a pulverizer to come back up to speed under reduced voltage depends on the type of pulverizer. Attrition mills unload as their speed drops and present no problem. Ball and bowl mills tend to have a constant torque. Thus if the speed does not drop too far below pull-out speed where the torque is approximately 250 per cent, margin exists between motor and load torque even at 75 per cent voltage.

Starting ball or bowl mills under reduced voltage is more difficult since under reasonably favorable conditions approximately 125 per cent of full-load torque is required. Where a primary air fan is integral with the pulverizer, a motor with 170 per cent starting torque is used. Assuming the pulverizer constitutes 55 per cent of the motor load, this is equivalent to over 300 per cent of full-load pulverizer torque. Thus this type of pulverizer might be expected to start under reduced voltage and favorable coal conditions. Where a primary air fan is not integral with the mill, motors with 200 per cent starting torque are used. It is questionable whether this motor would be able to start under loaded conditions at 75 per cent voltage. This must be evaluated in terms of the probability of starting a pulverizer during the period of high current and low voltage following a bus transfer operation.

ASME-AIME Holds Joint Meeting

The Fifteenth Annual Joint Fuels Conference of the Fuels Division of the American Society of Mechanical Engineers and the Coal Division of the American Institute of Mining and Metallurgical Engineers was held at the Bellevue Stratford Hotel, Philadelphia, October 30 and 31.

The first session, on Thursday morning, was devoted to papers on domestic stokers. The afternoon session included a paper on the burning of pulverized anthracite at the Sunbury Station of the Pennsylvania Power & Light Company. Friday morning was devoted to papers on coal preparation and those in the afternoon included coal freezing, cyclone dust collectors, and the cost of coal and ash-handling equipment for small plants.

Operation at Sunbury Station

A comprehensive account of the coal-burning system and experience at the Sunbury Steam-Electric Station was given by **T. B. Richards,** superintendent of that plant.

The Pennsylvania Power & Light Co., which is the largest single user of anthracite in the United States, in 1949 completed the installation of four 400,000 lb per hr boilers at its new Sunbury Station. These burn pulverized anthracite and serve two 75,000-kw turbine-generators. A third turbine-generator, of 100,000-kw rating, was placed in service in 1951 and is supplied with steam by a single 800,000-lb per hr boiler. A fourth unit of like capacity, with reheat, is now under construction.

Whereas the 1949 boilers were designed to burn pulverized anthracite alone, the subsequent units were designed to burn a mixture of 30 per cent anthracite and bituminous coal.

At Sunbury "prepared anthracite" (a mixture of No. 4 and No. 5 buckwheat) is normally burned, but at times the supply becomes limited due to market demand for these smaller sizes and it is necessary to blend it with silt and bituminous coal. The silt runs very high in ash.

The high moisture content of the mixture made it necessary to provide facilities to thaw frozen coal, adequate pulverizing capacity to dry and pulverize the coal and facilities to blend the wet anthracite with bituminous when deemed necessary. Moreover, the low volatile content of the anthracite necessitated burners capable of providing a rich coal-air mixture, vertical downward firing, large fur-

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For a positive determination of what constitutes *clean* steel, Dampney has devised a simple, unique test — a positive color indication of bare metal that tells you when cleaning can be safely stopped . . . when surfaces are free from heat-transfer barriers and corrosion-breeding impurities.

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Making good boilers better — and extending Dampney protection to all types of power and processing equipment through formulations of silicones, ceramics, vinyls, asphaltums, and chlorinated rubber—is the continuing aim of Dampney Maintenance for Metal. Our thirty-five years' experience in carrying forward this program is yours to call upon freely.

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nace volume with refractory-covered walls in the ignition zone and a secondary air supply capable of scrubbing the flame along its entire downward path. Because of the high ash content large dust precipitators were required as well as large ash-handling facilities.

The mills, which are of the ball type, grind to a fineness of 92 to 95 per cent through 200 mesh. Two of the mills employ copper-molybdenum alloy steel balls and six have forged-steel balls.

The liners and fan blades of the mill exhausters are subjected to severe erosion. Replacement blades of diamond floor plate have been found satisfactory and inexpensive. Worn spots in liners are repaired with plastic chrome cement.

When very wet anthracite must be burned, ignition is stabilized by adding bituminous coal.

The first four steam generators which burn anthracite alone are operated with 13.8 per cent CO_2 at the air heater inlet which is equivalent to 40 per cent excess air. A small amount of bituminous coal is added at times to sustain combustion.

With a station coal rate of 1.02 lb per kw output, the net station heat rate is 11,800 Btu per kw-hr.

Discussion

In answer to questions, Mr. Richards stated that with anthracite, compared to bituminous coal, approximately twice the furnace volume is required, also twice the number of mills and that the investment in fuel burning equipment is approximately 40 per cent higher. The combined efficiency of the mechanical and electrostatic dust recovery equipment is 91 per cent and the high moisture in the fuel is responsible for the vapor plume discharged from the stack.

Cyclone Dust Collectors

A paper by **Prof. A. J. ter Linden,** of Delft University, Holland, read in abstract in his absence, described numerous types of cyclones tested in the laboratory at Delft, and analyzed mathematically the results of the tests.

Commenting on the efficiency of cyclones, the author observed that, contrary to general opinion, a cyclone does not need high gas velocity in order to obtain good efficiency. Rather, a well-proportioned cyclone will show good efficiency for the whole velocity range that may be encountered in practical use. Therefore, regulating devices are generally superfluous.

For high efficiency, multicyclones consisting of a number of small units in parallel, should be employed; although the efficiency of the group may be considerably less than that of the individual cyclones due to slight irregularities in the distribution of the gases.

Professor ter Linden believed ordinances which prescribe limits for dust content of the flue gases to be inadequate as they do not take into account the total amount of dust leaving the stack, the size of the particles, height of the stack, or nature of the surroundings. He offered the following recommendations for cases where the stacks are high:

1. For small grate-fired boilers with a maximum capacity of about 30 tons per hour, one or two complete cyclones in parallel, with the exhaust not exceeding 5 ft.
2. For larger grate-fired boilers, a highly efficient multicyclone. To prevent blocking up the small passages, the exhaust diameter of the cyclones should not be less than 5 in.
3. For pulverized-coal-fired boilers in an industrial or rural district, a highly efficient multicyclone or a multicyclone of simple design in combination with an electrostatic precipitator.
4. For pulverized-coal-fired boilers in a residential district, a multicyclone in combination with a highly efficient electrostatic precipitator.

Coal and Ash Handling for Small Plants

This was the subject of a paper by **C. A. Marshall** and **D. M. Given,** both of the Fairmont Coal Bureau, New York, dealing with plants burning from 300 to 30,000 tons of coal per year. Handling charges for coal and ash, were figured on the basis of cost per ton of coal burned.

Various systems were discussed and illustrated as having economic application to plants within this size range. These are listed, together with their approximate costs in the

TYPICAL INSTALLED COSTS OF HANDLING SYSTEMS

COAL USED, TON/YR	TYPE OF HANDLING SYSTEM		COAL SILO, TONS	TRACK TO SILO, TON/HR	INSTALLED COST, DOLLARS	
	COAL	ASH			COAL	ASH
300	MONORAIL HOIST		----	----	800	
2,000	or BIN FEEDER		----	----	800 to 3,700	
5,000	or LIFT TRUCK		----	----	1,200 to 5,000	
5,000	$SILO_1$	HOIST	120	25	14,000	1,000
9,000	$SILO_2$	PNEUMATIC	180	25	20,000	12,000
12,000	$SILO_3$	PNEUMATIC	240	25	27,000	16,000
18,000	$SILO_4$	PNEUMATIC	360	35	36,000	21,000
30,000	$SILO_5$	PNEUMATIC	600	50	42,000	25,000

[1] PORTABLE CONVEYORS ONLY FROM TRACK HOPPER TO ELEVATOR
[2] INCLUDES TRACK HOPPER AND CAR SHAKER

(Continued on page 71)

Huge Saucer Foundation for Submarine Reactor

THE saucer-shape foundation for the 225-ft steel sphere that is to house a nuclear submarine power plant being built by the Atomic Energy Commission for the U. S. Navy has been completed, and work on assembling the hull of the land-based prototype submarine is underway.

Known as the "Submarine Intermediate Reactor," this project is under the direction of the Knolls Atomic Power Laboratory operated at Schenectady for the AEC by the General Electric Company. The reactor, and the sphere enclosing it, are being built on a 4000-acre site at West Milton, N. Y., about 18 miles north of Schenectady.

The spherical design of the reactor building was adopted to give additional protection to operating personnel and to off-site areas during test operations beyond the many safety controls of the reactor itself.

Similar structures are widely used in the chemical and petroleum industries, but the West Milton sphere will be the largest ever constructed. In the remote event that simultaneously all other controls fail, the resulting release of radioactive material would be contained in the sphere which will have a net "free" space of more than 5,400,000 cu ft.

The outer periphery of the building will be 706 ft. The sphere will rest on the concrete saucer just completed which is 179 ft in diameter and 42 ft deep. A ring of steel columns set on concrete outside the structure and reaching to the middle of the sphere will give further support to the building. Welded steel plates will make up the skin of the ball. The plates will be hoisted into position by a derrick mounted on top of a temporary central steel tower. The derrick, now in place, reaches up 424 feet above ground level.

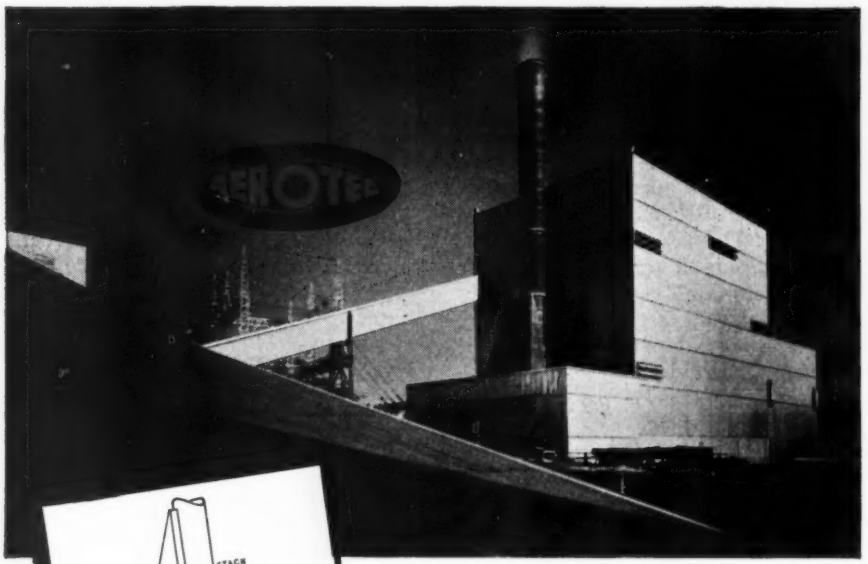
Every weld in the structure must be X-rayed to assure that there are no leaks. To do this on the bottom, a four-foot space is provided temporarily between the base of the sphere and the concrete saucer. After testing is completed, this space will be filled with concrete and aggregate. Inside, the concrete floor on which the reactor will rest will be slightly above ground level and the well of the saucer beneath the floor will be filled with compacted mixture of aggregate and earth. The reactor building will be air conditioned.

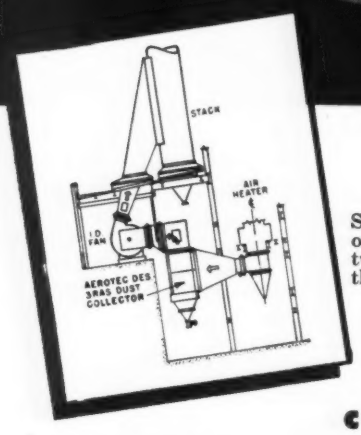
The hull of the submarine will be assembled just outside the building and skidded into the huge ball through a special wall section and the sphere again sealed.

The Submarine Intermediate Reactor is one of two nuclear science approaches being made to the problem of utilizing atomic fuel for under-water ship propulsion. The other is incorporated in a project at the National Reactor Testing Station in Idaho. The reactor designed for the West Milton site will use liquid sodium metal to take the heat out of the reactor core and into an exchanger or "boiler" where water will be converted to steam. The steam will then drive the turbines that propel the submarine.

Saucer base for reactor enclosure.

another power plant application of the
AEROTEC DUST COLLECTOR
promoting better community relations





Riverton Station
Northern Virginia Power Company

Sectional drawing shows location of AEROTEC Dust Collector between air heater and I.D. fan at this Riverton Station.

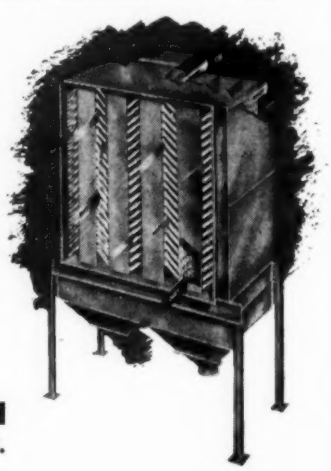
Promote your community relations the highly efficient Aerotec way

A clean stack has proven time and again to pay valuable dividends in community good will. To gain this advantage, plus plant erection and maintenance economies, public utilities are specifying the Aerotec Design 3 RAS Dust Collector. This unit develops a higher centrifugal force through the use of multiple, small-diameter tubes, resulting in exceptionally high efficiencies on ultra-fine dusts.

Flexible and space-saving

The tubes are permanent mold aluminum and closely nested to provide lighter weight and more capacity per square foot of plan area than any collector of comparable efficiency. They are set at a 45° angle on vertical tube sheets, factory-assembled into lightweight "building block" sections that reduce installation time and permit the Aerotec Design 3 RAS to be easily tailored to fit available space.

Our field engineers specialize in solving flyash collection problems and welcome the opportunity to assist you at any time. Call or write. No obligation.



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THE AEROTEC CORPORATION
GREENWICH, CONN.

Personals

Frank Christenson, executive vice president of Refractory & Insulation Corporation, New York, was recently elected president and chairman of the board of the Industrial Mineral Fiber Institute, formerly the Industrial Mineral Wool Institute.

Ray H. Timmons has been appointed manager of the Westinghouse Steam Division at the South Philadelphia Works. He has been with that company for the last 24 years in various capacities.

Joseph S. Imirie has been made assistant to the president of The Carborundum Company at Niagara Falls, New York.

Fred L. Plummer, director of engineering for the Hammond Iron Works, Warren, Pennsylvania, was elected president of the American Welding Society at its annual meeting in Philadelphia last month.

E. W. Petersen has been made general sales manager of American Blower Corporation. He has been with that company since 1923. Another recent appointment within the company was that of **R. L. Bernhard** as manager of the newly created Centrifugal Compressor Department.

Prof. **S. M. Marco** has been named chairman of the Mechanical Engineering Department at Ohio State University, succeeding Prof. A. I. Brown, who will devote his time to teaching.

Donald A. Burns has been made manager of publicity and advertising by the L. J. Wing Mfg. Company, Linden, New Jersey. He was formerly with John Moynahan & Associates, public relations counsel, New York City.

Big Power Plants to Supply New AEC Project

The new atomic energy plant to be built near Portsmouth, Ohio, as announced by AEC some weeks ago, will be supplied with power by two large steam plants, one near Madison, Indiana, and the other near Gallipolis, Ohio. These will have a combined capacity of 2,200,000 kw and will be built and operated by the Ohio Valley Electric Company, which was organized for this purpose. The Madison plant will have initially six 200,000-kw turbine-generators and the Gallipolis plant five of like capacity. They are expected to be in full operation by the middle of 1956.

REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Steam Power Stations, Fourth Edition

By Gustav A. Gaffert

This well-known book was first brought out in 1937 primarily to familiarize mechanical engineering students with steam power equipment and practice; but aside from fulfilling this objective, it has found wide favor among practicing engineers. This is as might be expected from the author's background, which combines both teaching of heat-power engineering and many years of experience in power station design, as mechanical engineer and partner in the firm of Sargent & Lundy, Chicago.

That it has been found expedient to bring out four editions over a period of fifteen years attests to the rapid developments that have taken place in power plant practice during that period. In general, statistics, data and other information have been brought through 1950, which is about as late as can be expected in view of the time required for revision, proofreading and production. Three new chapters have been added, namely, a general discussion of power equipment, heat transfer and optimum cycles.

This fourth edition contains 637 pages, 6 × 9 in., 433 illustrations and charts, including a Mollier Diagram, and many tables. It is priced at $8.

Interchangeability of Oil Gas and Natural Gas

By D. L. Nicol, R. A. Brown and H. R. Linden

This is an interim report sponsored by the Gas Production Research Committee of the American Gas Association. It deals with studies for improving the substitutability of oil gases for natural gas through modification of their compositions by one or more of these techniques:

(1) By mixing or dilution with inerts.

(2) By reduction or removal of specific aromatic hydrocarbons through scrubbing, freezing or compression.

(3) By control of severity of cracking in the production of oil gases.

The report presents an analysis of the combustion performance of oil gas and oil gas-natural gas mixtures substituted for two natural gases at the adjustment manifold pressure on seven selected critical appliance burners adjusted to soft, medium and hard flame settings on each of the two natural gases. It also includes a similar combustion-performance analysis on these same seven critical burners adjusted on selected oil gases.

Incorporating many curves and charts, the 28-page paper-bound report sells for $2.50.

American Pipe Lines

By George S. Wolbert, Jr.

This book deals with the industrial structure, economic status and legal implications of oil pipe lines which move the preponderant part of America's oil requirements.

Presented in two parts, the book opens with a report on the historical, economic and technical development of pipe lines, including a discussion of the specific issues relating to industry rate and service requirements. The second part surveys existing legal and administrative remedies intended to cope with problems outlined in the first part. The actual influence on rate and service requirements exerted by decisions of the Interstate Commerce Commission and the way in which these matters are handled are discussed. The book contains an extensive running bibliography, and there are numerous references to legal cases pertaining to subjects explained.

The author of this 180-page book which sells for $3.50 is associate professor of law in Washington and Lee University.

Elementary Heat Power, Second Edition

By H. L. Solberg, O. C. Cromer and A. R. Spalding

Three faculty members of the School of Mechanical Engineering at Purdue University have collaborated in the revision of this text which places its basic emphasis upon fuels as sources of energy, the functions of the equipment used for power generation, the construction of such equipment, and its actual performance. It is intended for the students who have studied physics and chemistry at the college level and whose mathematical training includes the calculus.

The major changes made in revising the book were directed toward bringing together as many fundamental concepts as were logically feasible in the opening chapter entitled "Matter and Energy." To these ends, consideration was given to a discussion of the English engineering system of units and dimensions, development of the general energy equation and its application to heat-power equipment in terms of the first law of thermodynamics, early introduction of the concepts of entropy and enthalpy, and the significance of the second law of thermodynamics in relation to energy degradation. The material on combustion calculations was rewritten with the purpose of stimulating analytical thinking and developing facility of calculation using the pound-mole. Descriptive material in the text has been brought up to date so that it is indicative of that used in today's power plant operations.

The authors have had many years of teaching experience in a wide variety of heat-power subjects. They have succeeded in preparing an elementary text that should have wide use. It contains 624 pages and sells for $6.50.

Technical Calculations in Heat Engineering

By James H. Potter

Occasionally one comes upon a workbook intended primarily for student use in engineering schools that also has considerable value to the practicing engineer. Such is the case in this instance, for Professor Potter's book should be of considerable aid to the active engineer whose thermodynamics has become "rusty" and who wishes to make a systematic review, guided by a logical outline. Covering 150 problems in heat engines and thermodynamics, one to a page, the paper-spiral-bound workbook sells for $2.25.

Les Machines Thermiques

By Paul Chambadal

In September 1949 COMBUSTION published a review of a French text on the thermodynamics of the gas turbine by M. Chambadal, who is engineer in charge of research for Électricité de France. Now the same author has prepared a basic thermodynamics text suitable for use in the French counterpart of the third year in a typical American engineering college.

Following a review of the principal thermodynamic transformations and their graphical representation, the author explains a number of different combinations of these transformations which constitute the various thermal cycles, including both heating and refrigeration. The manner in which engines, turbines, compressors and the like function is explained in considerable detail, along with the types of fluids employed in these machines.

There are 71 line-cut illustrations in this 216-page paper-bound French text which sells for $1.50.

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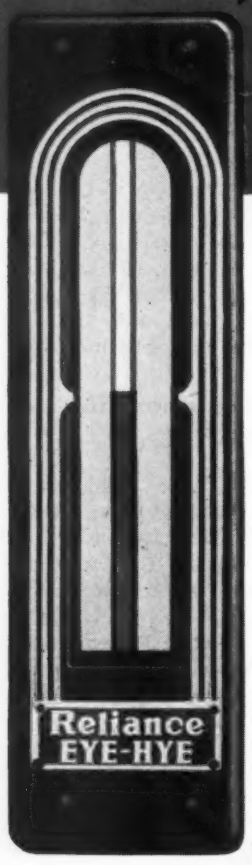

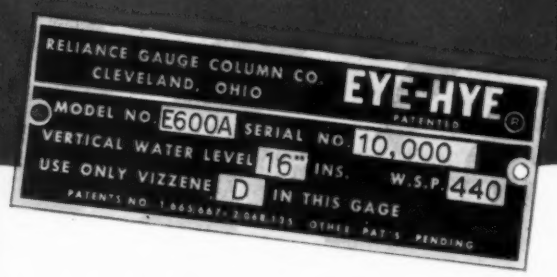
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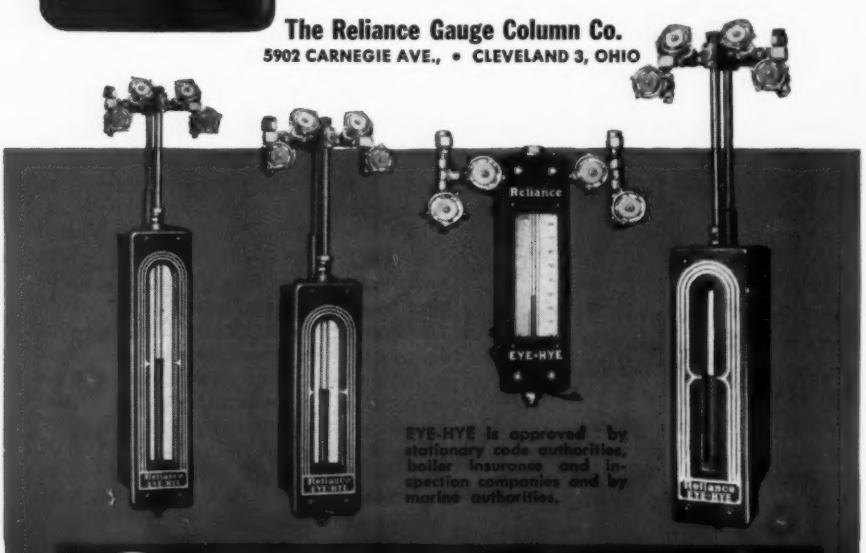
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EYE-HYE is approved by stationary code authorities, boiler insurance and inspection companies and by marine authorities.

Reliance EYE-HYE
Remote Reading Gage
All-hydrostatic • Reads like a tubular glass gage

New Catalogs and Bulletins

Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York 16, N. Y.

Boiler Water Conditioning

A 12-page catalog outlining difficulties caused through industrial water contamination has been prepared by E. F. Drew & Co. It contains a list of recommended water-conditioning treatments for scale, sludge, corrosion, carry-over and other boiler conditions.

Gate Valves

Publication of a 6-page catalog describing a new line of cast steel gate valves has been announced by Edward Valves, Inc. It contains information on details of design, material specifications and dimensional values and weights of cast steel valves in the 300, 600, 900 and 1500 psig classes which are furnished in sizes from $2^1/_2$ in. through 12 in.

Pneumatic Controller

Fischer & Porter Company have issued a 20-page catalog which describes the Type P-4 "Pneumatrol" controller for rate of flow, differential pressure, liquid level, viscosity, pressure and temperature applications. Action and components of the controller are explained in detail.

Liquefied Gases

An attractive 24-page catalog summarizing the work of Arthur D. Little, Inc., in the production, handling and storage of liquefied gases has been prepared by the Mechanical Division of that organization. It also includes a description of a high-field-strength electromagnet and tells of the availability of a professional staff specializing in the development of prototype equipment.

Surface Condensers

An exceptionally attractive 32-page booklet, "Radial-Flow Surface Condensers," is available from the Westinghouse Electric Corp. Color diagrams illustrate heat transfer, surface activity and deaeration of condensate. Shop photos show shell-construction types, method of installing tube supports and plates, and provisions for differential expansion. A two-page cutaway view with a colored overlay clearly explains steam and air flow in a two-pass condenser.

(Continued from page 67)

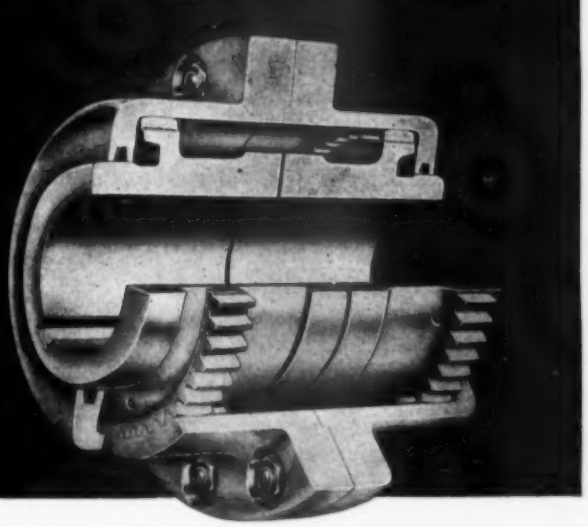
preceding table. It was contended that the total coal- and ash-handling including fixed charges, maintenance, power and labor could be held within a dollar per ton of coal consumed. It was pointed out, however, that this figure would not support full-time handling labor at an annual wage of $3600 if the plant burned less than 15,000 tons of coal per year. For such plants other duties should be included.

Within the size range assumed, it was estimated that maintenance costs would average from 15 to 25 cents per ton.

At the banquet on Thursday evening which was addressed by A. A. Potter, dean of Engineering at Purdue University, the Annual Percy Nicholls award was made to H. F. Yancey, of the U. S. Bureau of Mines. The presentation was made by A. W. Thorson, chairman of the Award Committee.

We have had several inquiries as to the identity of the rather unusual September cover photograph captioned "A Study in Reflections." This is the Lumberton steam-electric generating station of the Carolina Power & Light Company at Lumberton, North Carolina.

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

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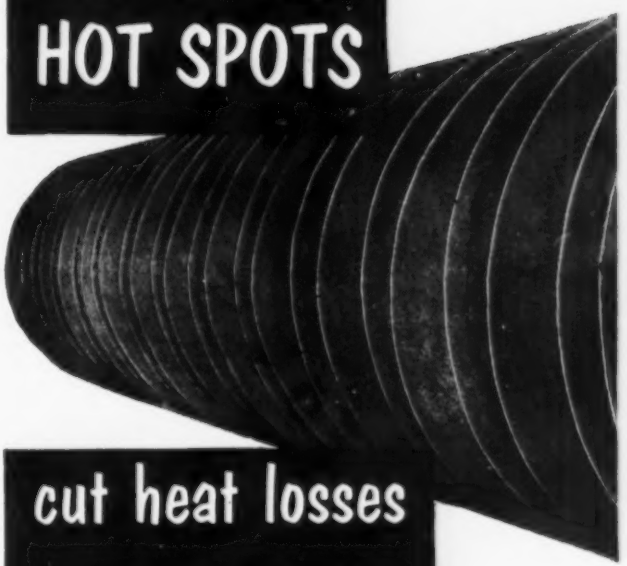

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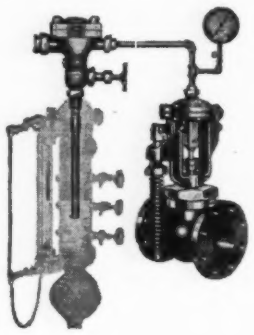
IN LOUISIANA

An ATLAS representative writes as follows about boiler troubles in a Louisiana sawmill. After solving the difficulties he says:

"Each boiler was supplied with a

CAMPBELL
Boiler Feed Water Regulator

—in which no floats, thermostats, or generators were involved in the design or construction. A continuous blowdown feature was incorporated in the unit."



He concludes:

"The plant now has ample dry steam, with more excess fuel than can be burned under the boilers."

Users of the CAMPBELL Like These Six Points:

1—Continuous Blowdown;
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3—No Thermostats;
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The CAMPBELL has been controlling all types and sizes of boilers for many years—SUCCESSFULLY. Note the INDICATING GAGE (shown above) which can be placed on the switchboard or control board showing what the regulator is doing at all times.

Slightest changes in water level cause the CAMPBELL to operate the largest control valves instantly. Rugged. Efficient. Economical. No fine adjustments. Easy to install. 50 to 400 lb. pressure and up.

Sizes 1" to 6". Guaranteed by a concern that has been in the regulating valve business EXCLUSIVELY for more than a half century.

Using the coupon below will save time;

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REGULATING VALVES FOR EVERY SERVICE

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Without obligation, please send data on the CAMPBELL Boiler Feedwater Regulator. Also, please send complete information on the following ATLAS products:

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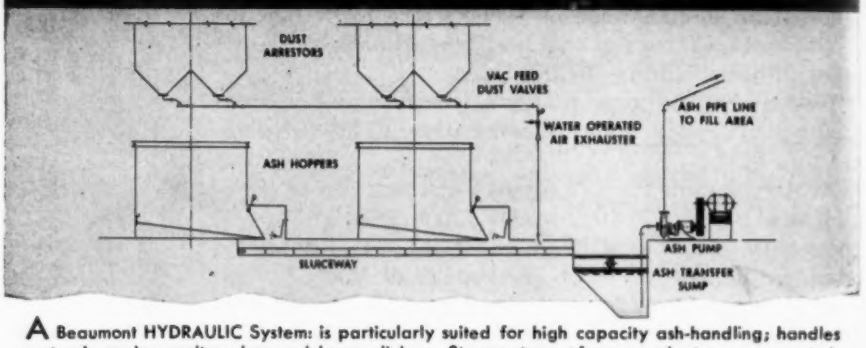

A Beaumont HYDRAULIC System is particularly suited for high capacity ash-handling; handles wet ash or dry, molten slag and large clinkers; fits any type of power plant arrangement; is completely enclosed, preventing dust or gas from escaping to the boiler room; and can be operated by one man on a part time basis.

Beaumont's Ash-Handling Division is competently staffed to give you expert recommendations on all types of ash-handling systems . . . and to provide and install the proper equipment to suit your particular requirements. Write today for the Beaumont brochure: "Answers to Your Ash-Handling Questions".

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DESIGNERS—MANUFACTURERS—ERECTORS BULK MATERIAL HANDLING SYSTEMS

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VERTICAL TURBINES
Economical—Dependable . . . for
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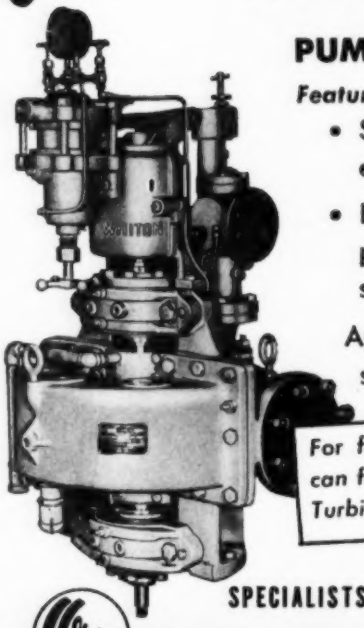

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Announcing...RCA Industrial TV

offering 5 important features

Now RCA offers closed-circuit (wired) television specially designed for all types of industrial applications. By means of this new type of Industrial Television, you can maintain continuous visual checks on remote, inaccessible, or hazardous operations—from one or more points—with clear, high-contrast pictures. RCA Industrial TV has the following five important features.

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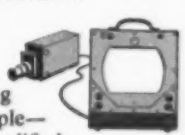

A rugged camera tube (Vidicon)—operating on an entirely new principle—has made possible the simplified RCA Industrial Television system. Camera and monitor are connected by a single cable. No intermediate equipment is necessary. No more tubes than an ordinary home television set. To place in operation, merely connect to 110 volts, 60 cycle AC.

2. Compactness

RCA's new Industrial Television Camera (3" x 5" x 10")—about the size of a 16mm movie camera—weighs only 7½ lbs. Using the Vidicon Tube, this camera is the smallest design available.

3. Ease of Operation

All controls—including those for the camera—are located on the monitor. For fixed operating conditions, once this system is set up, all necessary adjustments can be made with only two knobs . . . operation has been so simplified, anyone can learn to obtain a clear picture in a few minutes.

4. Picture Quality

With an RCA Industrial TV you can obtain high quality pictures without excessive illumination. Scanning frequencies are 525 lines, 30 fields, 60 frames, interlaced . . . the same as standard broadcast television. This permits home television sets to be used as auxiliary viewers.

5. Ease of Service

Carefully engineered simplification of circuits and components has resulted in dependability and ease of service and preventive maintenance. When you buy RCA Industrial Television, you can also buy an RCA Service Plan—complete nation-wide service by trained experts of the RCA Service Company.

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BOOKS

1—Fuels and Combustion Handbook

ALLEN J. JOHNSON, EDITOR AND GEORGE H. AUTH, ASSOCIATE EDITOR

915 pages Price $12.50

The objective of this practical handbook is to bring together for ready reference representative factual material on fuels and combustion. Much of this information heretofore had to be searched for in pamphlets and articles scattered throughout the trade press and in publications of government bureaus and engineering societies.

More than 450 major references were used by the editors in compiling the handbook. It is estimated that 50 per cent of the material is less than five years old and over 80 per cent less than ten years old. The scope is sufficiently broad to interest fuel technicians, engineers and operating men.

The handbook is characterized by an unusually large number of tables of data and by the extensive use of alignment charts for rapid computations. The nomograph method of computing heat balances has been presented in quite some detail.

There are eight sections in the handbook, covering solid fuels, liquid and gaseous fuels, combustion, fuel selection, coal preparation, fuel-handling methods, heat transfer and steam generation, and test procedures. Many recent developments in the broad field of combustion are discussed, including those associated with synthetic fuels, the heat pump, gas turbines, and spreader stokers. One very interesting chapter is entitled "Factors Involved in the Selection and Purchase of Fuel."

2—Radiation Monitoring in Atomic Defense

BY D. E. GRAY AND J. H. MARTENS

122 pages Price $2.00

Current interest in civilian defense programs makes this book especially timely. Part I is devoted to background information on atomic and nuclear energy and the hazards that are produced during and after an explosion. Much of this section can be understood by readers with no technical background. Consideration is given to protective measures and to means of measuring and detecting nuclear radiations.

Part II takes up instruments and equipment in radiation detection. It describes the basic construction and characteristics of a number of specific radiation detection devices and gives instructions for their operation and maintenance.

3—Steam and Gas Turbines

BY B. G. A. SKROTSKI AND W. A. VOPAT

395 pages 6 × 9 Price $5.00

As might be expected from the relative use and state of development of the two types of prime movers, about 80 per cent of the text is given over to steam turbines and 20 per cent to gas turbines.

Intended primarily for operating engineers, the book is informative to anyone in the power field and might well be employed as a reference text for students, despite the absence of problems.

An elementary approach is employed in describing turbine types, followed by descriptions of commercial machines in greater variety than found in most other books on the subject. There follow chapters on lubrication, turbine governors, auxiliaries, maintenance and performance. The illustrations are simple and helpful.

Under gas turbines, descriptions of the simple cycle and closed cycles include a discussion of means for increasing efficiency through intercooling, reheating, etc. The same approach to the subject is employed as in the preceding chapters in steam turbines.

4—Sourcebook on Atomic Energy

BY SAMUEL GLASSTONE

546 pages Price $3.40

Following a request of the American Textbook Publishers Institute for a comprehensive sourcebook on atomic energy this book was prepared by Dr. Samuel Glasstone at the instance of the Atomic Energy Commission. It brings together important facts about the past history, present status and possible future of atomic science. While the work has been termed a "primer" on the whole subject of atomic science, the very complexity of the topics under discussion makes for some difficulty in reading and comprehension. On the whole it is written in language as simple as is compatible with the subject.

Throughout the book a historical approach is used wherever possible to describe the growth of thought and knowledge in the atomic field. Some mathematical expressions have been found necessary to explain certain atomic developments, but most of the equations are intelligible to those with a knowledge of algebra.

An idea of the scope of the book may be had from the following representative chapter titles: Constituents of the Atom, Natural Radioactivity, Nuclear Radiations, Isotopes, Nuclear Transmutation and Artificial Radioactivity, The Neutron, Nuclear Fission, The Utilization of Nuclear Energy, The Uses of Isotopes, Cosmic Rays and Mesons, and Radiation Protection and Health Physics.

5—Steam Plant Operation Second Edition

BY EVERETT B. WOODRUFF AND H. B. LAMMERS

542 pages 6 × 9 Price $7.00

This book, originally brought out in 1935, is aimed at presenting a practical text for the guidance of engineers engaged in operating stationary steam plants. It provides basic information on the combustion of fuels, types and certain construction details of fuel-burning equipment, boilers, their settings and auxiliaries; also steam engines and turbines together with their auxiliaries. Moreover, considerable space is given to the safe and efficient operation and maintenance of steam plant equipment. At the end of each chapter is a list of questions, with specific text references as to where the answers can be found. This feature should be of great assistance to those preparing to take examinations for an operating license.

In the present edition the text has been largely rewritten to bring it up to date as regards present designs of equipment and current practice.

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